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Discounting of Delayed and Probabilistic Rewards by Women with and without Binge Eating Disorder

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DISCOUNTING OF DELAYED AND PROBABILISTIC REWARDS BY WOMEN WITH AND WITHOUT BINGE EATING DISORDER

by

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ABSTRACT OF THE DISSERTATION

Discounting of Delayed and Probabilistic Rewards by Women with and without Binge Eating Disorder

by

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Doctor of Philosophy in Psychology

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Professor Denise Wilfley, Chair

Obese individuals with binge eating disorder (BED) exhibit more general and eating-disordered psychopathology than obese individuals without BED. Binge eating also impedes weight-loss efforts, already difficult in an obese population. A better basic understanding of binge eating and obesity is needed to refine treatments for both conditions. Discounting, an experimental paradigm that examines changes in the value of delayed or uncertain outcomes, may provide an objective assessment of impulsive behavior. Impulsivity may perpetuate binge eating, but discounting tasks have never been evaluated with eating disordered individuals. A discounting procedure could help differentiate individuals with eating/weight problems from controls in terms of impulsive behavior and the relative value of rewards. This study compared discounting rates of food, money, sedentary activity, and a control variable among 30 obese women with BED, 30 obese women without BED, and 30 normal-weight controls. Relations were examined between questionnaire measures of psychopathology and discounting rates; and between obesity and binge eating and discounting rates. The BED group discounted delayed and probabilistic rewards overall more steeply (impulsively) than Obese and Controls, with no difference between the latter two groups. Further, the BED group discounted delayed food more steeply than money as compared to Obese and

Controls. Delay and probability discounting rates were correlated with general psychopathology but not eating disorder psychopathology, obesity, binge eating, or self-report impulsivity questionnaires. These results indicate that women with BED choose rewards more impulsively, especially with food, and are more risk averse, than obese or normal-weight women, and obese and normal-weight women do not differ in their impulsive decision-making. General psychopathology, but not scores on impulsivity questionnaires, was correlated with discounting rates, portending further research into the relationship between impulsive decision-making and other psychological disorders, and providing further support of the multidimensionality of impulsivity. The more impulsive decision-making by the BED group suggests a temperamental difference in this eating disorder that cannot be accounted for by the concomitant obesity. Future research should examine the predictive power of discounting within individuals with BED and its amenability with psychological treatment, which also would aid in developing prevention and treatment programs for other impulse-control disorders.

INTRODUCTION

Introductory Concepts

Binge eating -- eating an unambiguously large amount of food accompanied by a sense of loss of control -- is a hallmark of the eating disorders bulimia nervosa and binge eating disorder (BED; American Psychiatric Association, 1994). In addition to the numerous health consequences associated with obesity (National Task Force on the Prevention and Treatment of Obesity, 2000b), obese individuals with BED compose a distinct subset of this population, with a large number of studies consistently demonstrating robust differences between the clinical profiles of obese individuals with, and obese individuals without, BED (Marcus, 1993; Yanovski, Gormally, Lesser, Gwirtsman, & Yanovski, 1994). In comparison to non-BED obese, obese individuals with BED have more chaotic eating habits, consume larger amounts of food between binge episodes, exhibit higher levels of eating disinhibition (i.e., eating in response to emotional states), suffer from significantly higher levels of eating disorder psychopathology, and have higher rates of psychiatric comorbidity (e.g., Wilfley, Schwartz, Spurrell, & Fairburn, 2000; Wilson, Nonas, & Rosenblum, 1993; Yanovski et al., 1992). The presence of binge eating, distressing in and of itself, also impedes weight-loss efforts, already difficult and important in an obese population (McGuire, Wing, Klem, Lang, & Hill, 1999; Orzano & Scott, 2004). Cognitive behavioral therapy and interpersonal psychotherapy have demonstrated effectiveness in their treatment of BED (Wilfley et al., 2002); even so, approximately one-third of these patients relapse after treatment ends (Grilo, Masheb, & Wilson, 2005; Safer, Lively, Telch, & Agras, 2002). Clearly, there is a need to understand better the nature of binge eating and obesity in order to both develop and refine treatments for both disorders. One way to move clinical science forward is by incorporating research from different but complementary fields to augment our knowledge base.

Binge eating is an example of the common practice of engaging in a short-term behavior that is counter to one's overall long-term best interest (Petry, 2003). Impulsivity and self-control have been implicated in the maintenance of binge eating (e.g., Claes, Vandereycken, & Vertommen, 2005), and one of the main defining features of binge eating is a feeling of "losing control" over eating, but few studies have examined the more basic relationship between binge eaters and their choice of food. It is not known whether individuals with eating or weight problems ascribe greater value to food and/or sedentary activity than individuals without these problems, and fully understanding this relationship has been further limited by participants' difficulty in adhering to long-term diet and exercise programs (Epstein, 1992; Prentice et al., 2006). Using basic research to determine the components that influence behavior (a 'bottom up' approach) is just as essential to understanding binge eating and obesity as applied studies that use the knowledge obtained from more basic research ('top down'; Epstein, 1998; Staddon & Bueno, 1991).

Behavioral choice theory, or behavioral economics, is one learning approach with clinical implications to the understanding of decision making, which studies how time and responses are allotted depending upon the options presented to the individual (Epstein, 1998; Rachlin, 1989; Vuchinich & Simpson, 1998). One of the main principles of this approach is that choice depends on the span of time occurring between choosing and receiving the alternatives. When two reinforcers are available immediately, individuals typically will opt for the larger reinforcer; however, if the larger reinforcer is delayed, individuals now have a more difficult choice and may choose impulsively by selecting the smaller, but more immediate, reinforcer (Green & Myerson, 2004; Rachlin, 1989). In other words, the larger reinforcer has been *discounted* because of its delay. Delay

discounting[1] refers to the decrease in the subjective value of a reward as the time until its receipt increases (e.g., most people would prefer $40 today than $40 in a week), whereas probability discounting refers to the decrease in the subjective value of a reward as the likelihood of its receipt decreases (e.g., most prefer a 90% certainty of $40 over a 10% certainty of $60). The discounting model has been proposed as an underlying mechanism for behavioral problems such as substance abuse (Rachlin, 1990) and other addictions (Ainslie & Haendel, 1983; Petry, 2001a; Raineri & Rachlin, 1993), and offers a significant advancement to current psychological theories of impulsivity and self-control (e.g., Ainslie, 1992; Bickel & Marsch, 2001; Green & Myerson, 1993; Logue, 1988).

Despite the purported role of impulsivity (and its counterpart, self-control) in binge eating and obesity, a discounting paradigm has never been used to investigate the behavior of this population (Wogar, Bradshaw, & Szabadi, 1992). The use of a discounting procedure could help differentiate obese from non-obese, and binge eaters from non-binge eaters in terms of impulsive behavior and/or self-control by asking these individuals to choose between valued rewards such as food and money that are available at different delays or with different probabilities.

Impulsivity has been defined as the choice of a smaller, more immediate reward over a larger, more delayed reward, with self-control as the opposite (Rachlin & Green, 1972). This definition has been extended by also including small immediate rewards that have delayed negative consequences, such as having dessert now and having bad health later (Rachlin, 1974). Given this definition of impulsivity, the discounting task may provide an objective assessment of impulsivity. For example, when a smoker decides to refuse a single cigarette, s/he is choosing an uncertain but larger reward (future good health) over a more-probable but smaller reward (pleasure of smoking; Rachlin, 2000).

[1] See Appendix A for a glossary of terms used throughout this work.

For substances or activities considered to be addictive such as drugs, alcohol, and gambling, the harmful effect of present consumption on future well-being is particularly strong (Green & Kagel, 1996).

Food is often thought of as 'addictive'; indeed, consuming abused substances and food appears to activate the same "pleasure" centers in the brain (e.g., Simansky, 2005), but whereas the addiction process may be similar in food and drug cravings (Cassin & Von Ranson, 2007), the neural sensitization in dopamine-related systems that are caused by drugs, but not by food, amplifies drug addiction to a state unlikely to be matched by most food rewards (Berridge, 1996; Di Chiara, 2005; Robinson & Berridge, 1993). Nonetheless, food is very reinforcing both physiologically (e.g., stimulates taste buds, dopamine receptors) and psychologically (e.g., through learned associations of smell and taste), which provides just one of the reasons for the disparate rise in obesity coupled with the desire for thinness (Epstein et al., 2004; Hedley et al., 2004). Food-related behavior is also an activity that can be easily reconciled with the concepts of impulsivity and self-control, as measured by a discounting task. For example, over a decade, most people would agree that they prefer to be healthy than to be a couch potato and/or glutton; however, most people would rather, right now, sit on the couch than go to the gym, and eat the slice of cake rather than abstain (Rachlin, 2000). This conundrum, based on whether one is choosing to heed the short- or long-term outcome, forms the basis of using delay and probability discounting to measure impulsivity and self-control.

The introduction will discuss behavioral choice theory, discounting, impulsivity, and self-control; how these concepts pertain to the clinical population of binge eaters and obese individuals; and the aims and hypotheses of the current proposal.

Behavioral Choice Theory

Research on learning, cognitive psychology and decision-making, and economics have all contributed to behavioral choice theory, which has proposed several general principles of choice behavior (Epstein, 1998; Frederick, Loewenstein, & O'Donoghue, 2002; Herrnstein, 1974; Kahneman & Tversky, 1973). Many factors influence choice behavior; impulsive behavior and self-control are two salient psychological concepts that have been studied for their role in choice behavior. As stated above, one of these principles, and the basis for this study, is that the delay before receiving a reinforcer influences the choice behavior. The application of this principle to diet and physical activity is apparent to most people making a choice between the immediate pleasurable benefits of 'junk food' and sedentary activity, and the delayed benefits of healthy food and physical activity. Another principle of behavioral choice theory states that the choice of an alternative depends on its behavioral cost (Bickel, DeGrandpre, Higgins, & Hughes, 1990); thus, the proposal that low-nutrient-dense snack foods should be taxed in an effort to curb the rise of obesity (Wang & Brownell, 2005). A third principle is that the choice and reinforcing value of a reward depend partially on the alternatives available to the individual; hence, the success of contingency-management procedures that reward abstinent drug users with monetary incentives (Bickel, Amass, Higgins, Badger, & Esch, 1997; Epstein, 1998), and the treatment strategy for overeaters of 'finding alternatives to binge eating' (Fairburn, 1995). It also can be seen how this principle lends itself well to testing by the discounting paradigm, which asks the participant to choose among various alternatives.

Finally, behavioral choice theory states that voluntary choice is an important motivator to obtain a reinforcer. Again, this principle is apparent in, for example, recommendations that weight-loss interventions provide choices among healthy

alternatives (Nicklas & Johnson, 2004), instead of the individual being forced into a recommended diet regimen.

A choice always involves both a rational decision about which reinforcer is more valuable, as well as individual differences in one's ability to wait for the larger, delayed reinforcer (i.e., exhibiting self-control; Rachlin, 1989). It is this latter concept in which the current work is interested.

Discounting

Introduction

In 1937 the economist and later Nobel laureate Paul Samuelson proposed the discounted utility model, and although he had reservations about its descriptive validity, this simple and elegant model was quickly embraced as the framework with which to examine choice decisions (Frederick, Loewenstein, & O'Donoghue, 2002; Samuelson, 1937). This economic approach, which derives a formula from theoretical assumptions about what organisms ought to do, is represented by an exponential equation. Psychologists and behavioral economists, for their part, have favored a hyperbolic equation to better describe how organisms actually behave, instead of normative behavior proscribed by the discounted utility model (Ainslie, 1992; Green & Myerson, 1993; Madden, Begotka, Raiff, & Kastern, 2003; Myerson & Green, 1995). The hyperbolic delay discounting function is:

$$V = A/(1+kD)^S \quad (1)$$

where V represents the subjective value of a future reward of amount A, the parameter k governs the rate of discounting, D is the delay until receipt of the reward, and the exponent s may reflect the nonlinear scaling of amount and/or time (Ainslie, 1992; Green, Fry, & Myerson, 1994; Myerson & Green, 1995). Figure 1 shows the change in subjective value of monetary rewards as a function of delay to the reward (data are from

Green, Myerson, & Ostaszewski, 1999, *Journal of Experimental Psychology: Learning, Memory, & Cognition, 25,* p. 423). The symbols represent the group median subjective value of a $200 (circles) and a $5,000 (squares) delayed reward, plotted as a proportion of the amount of the delayed reward. The curves represent the best-fitting hyperboloid (Equation 1) fit to the obtained data.

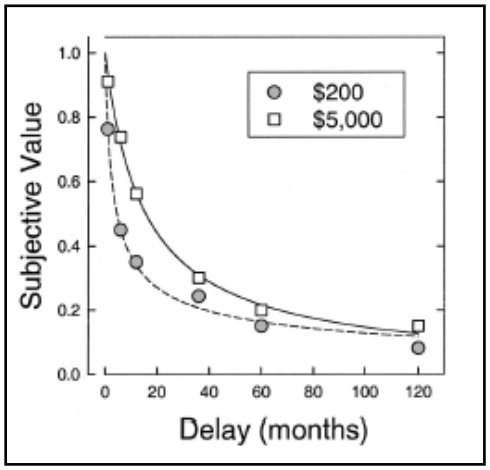


Figure 1.
Subjective value as a function of delay until receiving a reward.

A mathematically equivalent form (i.e., a hyperboloid) for probability is:

$$V = A/(1+h\theta)^S \qquad (2)$$

where V represents the subjective value of a probabilistic reward of amount A, parameter h reflects the rate of decrease in subjective value, θ represents the odds against receipt of a probabilistic reward (where $\theta = (1 - p)/p$, where p is the probability of receipt), and the exponent s may reflect the nonlinear scaling of amount and/or odds against (Green, Myerson, & Ostaszewski, 1999; Ostaszewski, Green, & Myerson, 1998). Figure 2 shows the change in subjective value of probabilistic $200 and $5,000 rewards (expressed as a proportion of their nominal amounts) plotted as a function of the odds against their receipt. The curved lines represent the hyperbola-like discounting function (Equation 2) fit to the obtained data. Data are from Green, Myerson, & Ostaszewski, 1999, *Journal of Experimental Psychology: Learning, Memory, & Cognition, 25,* p. 423.

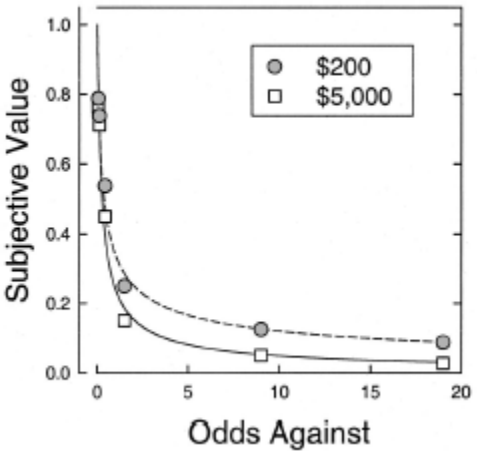


Figure 2.

Subjective value of probabilistic rewards as a function of the odds against their receipt.

Changes in the value of delayed or uncertain outcomes may be viewed from the perspective of the discounting framework (Green & Myerson, 2004). If an individual finds it difficult to sustain the choices s/he made for a reward (e.g., waiting to get intoxicated), this individual should discount the value of that reinforcer (e.g., alcohol) *more* steeply as a function of delay than reinforcers for which s/he does not find as difficult to sustain choice. For example, it might be anticipated that a heroin addict will have a more difficult time delaying gratification for heroin than for other reinforcers, such as money. Such individuals should discount the value of heroin more rapidly when its receipt is delayed than other 'less intense' reinforcers not involving addiction (Reynolds & Schiffbauer, 2005).

According to the discounting model, there should also be a relation between impulsiveness and addiction. The positive effects associated with, for example, excessive food intake, such as pleasant tastes and satiation, occur within seconds or minutes of intake; conversely, the more negative effects of excessive food intake usually are delayed in time as health consequences and weight increase occur gradually; the delayed negative effects are thus discounted. The steeper the rate of discounting, the less those negative delayed effects should weigh in current decisions regarding whether or not to overeat, or in another example, to abuse drugs. Therefore, steeper discount

rates (larger values of *k*) should be associated with deleterious behaviors and addiction (Kirby & Petry, 2004).

The similarity between the mathematical functions of delay (time until receipt) and probabilistic (likelihood of receipt) discounting has led to speculation that these two forms of discounting may be accounted for by similar underlying processes (Green & Myerson, 1996; Holt, Green, & Myerson, 2003; Prelec & Loewenstein, 1991; Rachlin, Siegel, & Cross, 1994; Stevenson, 1986). However, although the same mathematical formula accurately describes the discounting of both delayed and probabilistic rewards, significant differences between the two types of discounting are apparent, and most researchers treat delay and probability discounting as separate phenomena (Kalenscher, 2006). First, the discounting of delayed and probabilistic rewards is affected by amount of reward in opposite ways. That is, as the amount of a *delayed* reward increases, the rate of discounting decreases; conversely, as the amount of a *probabilistic* reward increases, the rate of discounting increases (Du, Green, & Myerson, 2002; Green, Myerson, & Ostaszewski, 1999; Myerson, Green, Hanson, Holt, & Estle, 2003; Prelec & Loewenstein, 1991). Second, the rate that probabilistic rewards are discounted appears to increase continuously with amount, whereas the rate of discounting delayed rewards has been found to level off at approximately $25,000 (Green, Myerson, & McFadden, 1997; Green, Myerson, & Ostaszewski, 1999). Third, inflation has been found to affect the rate of discounting involving delayed rewards, but not probabilistic rewards (Ostaszewski, Green, & Myerson, 1998). Fourth, the scaling parameter of the discounting function (*s*) is unaffected by amount of delayed reward, but increases as the amount of the probabilistic reward increases (Myerson, Green, Hanson, Holt, & Estle, 2003).

Finally, if delay and probability discounting reflect the same underlying trait, such as impulsivity or risk-taking, then the discounting rates between them should be

negatively correlated within the same individual. This is because steep delay discounting would reflect an inability to wait for delayed rewards, whereas shallow probability discounting would reflect a tendency toward risk-taking, because the subjective value of probabilistic rewards would decrease relatively little as risk increased (e.g., Green & Myerson, 2004; Myerson, Green, Hanson, Holt, & Estle, 2003). However, this negative correlation has not been found (Alessi & Petry, 2003; Holt, Green, & Myerson, 2003; Myerson, Green, Hanson, Holt, & Estle, 2003; Ohmura, Takahashi, Kitamura, & Wehr, 2006; Olson, Hooper, Collins, & Luciana, 2007). Another study found that delay discounting differed among participants with different personality temperaments as measured by questionnaire, but that probability discounting did not differ among these same participants (Ostaszewski, 1997). Thus, it appears that evidence is currently against a *unitary* underlying mechanism for delay and probability discounting, although the decision-making processes involved in each is likely similar (Green, Myerson, & Ostaszewski, 1999).

Anomalies

Even as Samuelson proposed the discounted utility model in 1937, he cautioned that its descriptive validity may not hold for *all* individual behavior (Samuelson, 1937); indeed, individuals demonstrate several inconsistencies that violate the theory of rational behavior that would be predicted if the discounting function was the only determinant used in maximizing behavioral utility (Frederick, Loewenstein, & O'Donoghue, 2002). Decision makers do not use a single discount rate for all decisions, but rather adjust their rates according to a number of factors (Chapman, 1998; George Loewenstein & Thaler, 1989). First, as noted previously, discount rates are not constant over time as predicted by an exponential function, but decline hyperbolically (Chapman, 1996; Kirby, 1997). Discount rates tend to be steeper for shorter delays than for longer delays, and when a discount rate is steep, a person is unlikely to use future rewards to guide current choices

(Chapman & Elstein, 1995; Kirby & Guastello, 2001; Thaler, 1981). Second, in what is known as the *magnitude* effect (see Figure 3), discount rates depend not only on the time delay, but also on the amount of the outcome. Larger delayed amounts of rewards (e.g., $10,000) are discounted less steeply than smaller delayed amounts (e.g., $100; Kirby, 1997). This effect has been shown with individuals discounting both real and hypothetical money (Benzion, Rapoport, & Yagil, 1989; Green, Fristoe, & Myerson, 1994; Green, Fry, & Myerson, 1994; Green, Myerson, & McFadden, 1997; Holcomb & Nelson, 1992; Johnson & Bickel, 2002; Kirby, 1997; Kirby & Marakovic, 1996; Kirby, Petry, & Bickel, 1999; Myerson & Green, 1995; Raineri & Rachlin, 1993; Shelley, 1993; Thaler, 1981), hypothetical health outcomes (Chapman, 1996; Chapman & Elstein, 1995), as well as medical treatments, vacations, and use of a rental car (Baker, Johnson, & Bickel, 2003; Raineri & Rachlin, 1993; Schoenfelder & Hantula, 2003). The magnitude effect has been shown to be opposite with probabilistic rewards; that is, smaller probabilistic rewards are discounted less steeply than larger probabilistic rewards (Christensen, Parker, Silberberg, & Hursh, 1998; Du, Green, & Myerson, 2002; Green, Myerson, & Ostaszewski, 1999; Myerson, Green, Hanson, Holt, & Estle, 2003).

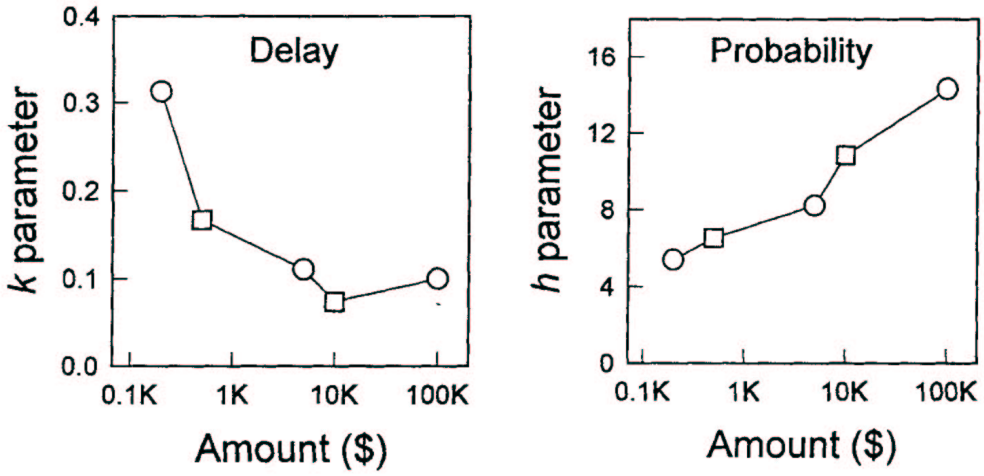
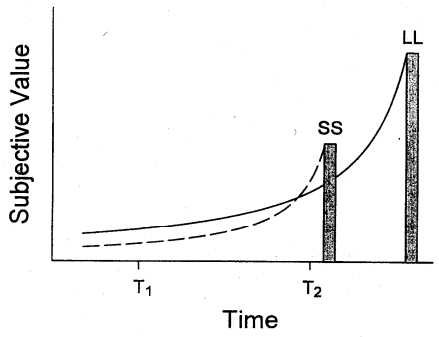


Figure 3. Illustration of the magnitude effect. Rate of discounting (*b*) of delayed and probabilistic rewards as function of amount. From Green, Myerson, & Ostaszewski, 1999. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 25(2). 418-427.

Third, although individuals often choose the smaller, more immediate reward over a larger, delayed reward, this preference reverses if delays to both rewards are increased equally. Preference reversals have been shown for humans and animals in both delay discounting tasks (Ainslie & Herrnstein, 1981; Green & Estle, 2003; Kirby & Herrnstein, 1995; Mazur, 1987; Rachlin & Green, 1972; Rodriguez & Logue, 1988), and in probability discounting tasks (Rachlin, Castrogiovanni, & Cross, 1987). These studies indicate that the same individual may be 'impulsive' at short delays, but demonstrate more 'self-control' at long delays (Green & Myerson, 1993). For example, an individual may prefer $20 today instead of $30 in two weeks, but if the delays to both rewards are lengthened equally by two weeks ($20 in two weeks and $30 in a month), this individual then may likely choose the larger amount. Preference reversals may be represented as shown in Figure 4 (e.g., Ainslie, 1975). The vertical axis represents the subjective, or discounted, value of a future reward, and the horizontal axis represents time. In this representation, the further to the left, the further in time from the rewards, and moving to the right (from T_1 to T_2) represents moving closer in time to the rewards. The heights of

the bars represent the actual reward amounts. The curves show how their subjective values might change as a function of the time at which the rewards are evaluated. Such curves are termed discounting functions because they indicate how the value of a future reward is devalued with its delay. According to the representation in Figure 4, if one were offered the choice between the smaller-sooner (SS) and the larger-later (LL) rewards at time 1 (T_1), one would chose LL, whereas if one were offered a choice between the same rewards at time 2 (T_2), one would chose SS.

Figure 4.
Preference Reversal



Fourth, decisions in discounting tasks are often framed as a choice between two gains or two losses; in what is known as the *sign effect,* gains are discounted at a steeper rate than are losses (Baker, Johnson, & Bickel, 2003; Benzion, Rapoport, & Yagil, 1989; Chapman, 1996; Kahneman & Tversky, 1979; Loewenstein, 1988; MacKeigan, Larson, Draugalis, Bootman, & Burns, 1993; Thaler, 1981). For example, individuals have been found to delay discount hypothetical money gains at a steeper rate than hypothetical money losses (e.g., Benzion, Rapoport, & Yagil, 1989; G. Loewenstein, 1988). This effect also has been found when discounting health outcomes (Chapman, 1996; MacKeigan, Larson, Draugalis, Bootman, & Burns, 1993) and when

discounting tasks are presented to substance abusers (Baker, Johnson, & Bickel, 2003). In research examining the combination of the magnitude effect and the sign effect, Estle et al. (2006) found that at smaller amounts, delayed gains are discounted more steeply than delayed losses, but at larger amounts, probabilistic gains are discounted significantly more steeply than probabilistic losses. This suggests that positive and negative outcomes are not discounted via a unitary process (Estle, Green, Myerson, & Holt, 2006).

Correlates

Group differences in delay discounting rates have been found across the lifespan: children demonstrate the steepest discount rates (Olson, Hooper, Collins, & Luciana, 2007), with adults and older adults progressively less steep (Green, Fry, & Myerson, 1994). Both children and adults discount future rewards according to the same hyperboloid functions; it is the degree to which they discount that varies with age (Green & Myerson, 1993). Income also has been examined as a possible influence on discounting rate. Lower-income older adults were found to discount delayed rewards more steeply than upper-income older adults or younger adults. Further, no discounting differences existed between the upper income groups (Green, Myerson, Lichtman, Rosen, & Fry, 1996). In examining personality constructs and discounting, high or low levels of sensation-seeking, extroversion, and impulsivity were compared. Extraverted and highly impulsive individuals showed steeper discounting of delayed rewards (Ostaszewski, 1996; 1997) whereas high sensation-seeking and impulsive individuals showed steeper discounting of delayed losses (Ostaszewski & Karzel, 2005). Comparing the same groups on a probabilistic discounting task revealed that high sensation seekers showed less-steep discounting for more probabilistic rewards (less risk averse; Ostaszewski, 1997), whereas highly impulsive individuals showed less-steep discounting (more risk averse) for probabilistic losses (Ostaszewski & Karzel, 2005; Richards,

Zhang, Mitchell, & de Wit, 1999). Finally, cultural differences also have been assessed in discounting. Du et al. (2002) found that American and Chinese graduate students discounted delayed rewards more steeply than Japanese graduate students; however, the mathematical form of the functions across groups were similar. Thus, discounting tasks have been demonstrated as sensitive indicators of factors such as personality, age, and income.

Some research has examined biological correlates of discounting. In fMRI research, one study found that delay discounting differences were positively correlated with the magnitude of ventral striatum activation in response to both positive and negative feedback (Hariri et al., 2006). The ventral striatum has a role in mediating behavioral responses related to reward, and its dysregulation contributes to addiction (Kalivas & Volkow, 2005). Other fMRI studies have found convincing evidence that choices involving immediate rewards (Tanaka et al., 2004), and choices between a smaller, sooner reward and a larger, delayed reward (McClure, Laibson, Loewenstein, & Cohen, 2004; Monterosso et al., 2007), activate the limbic and paralimbic cortical reward systems. In contrast, in participants who chose the larger, later reward, brain areas involved in executive control (the lateral prefrontal and parietal cortices) were activated (McClure, Laibson, Loewenstein, & Cohen, 2004; Tanaka et al., 2004; Wittmann, Leland, & Paulus, 2007), providing evidence of differential neural activation depending on whether short- or long-term rewards are predicted (Tanaka et al., 2004). Delay discounting also has been found to be related to intelligence in adolescents (Olson, Hooper, Collins, & Luciana, 2007) and adults (de Wit, Flory, Acheson, McCloskey, & Manuck, 2007). Individuals with ADHD have been found to discount rewards more steeply than controls (e.g., Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001); this phenomena was further validated in a study that found *d*-amphetamine – an effective treatment for ADHD (Spencer et al., 2001) – decreased impulsive responding on a delay

discounting measure (de Wit, Enggasser, & Richards, 2002). In contrast to these findings, one study found that diazepam – an anxiolytic that has had effects on impulsive behavior in rats (Evenden & Ryan, 1996) but not humans (Reynolds, Richards, Dassinger, & de Wit, 2004) – had no effect on measures of delay or probability discounting (Acheson, Reynolds, Richards, & de Wit, 2006). Further, the opioid receptor antagonist naltrexone, one of the few approved treatments for alcoholism, did not reliably reduce impulsive choice (as measured by delay discounting) in abstinent alcoholics (Mitchell, Tavares, Fields, D'Esposito, & Boettiger, 2007).

Constructs

Before the literature on the discounting paradigm as applied to clinical populations can be reviewed, it is vital to reach a better understanding of the underlying constructs discounting is thought to assess. Delay of gratification, impulsivity, and self-control are all constructs that have been used to explain the results of discounting tasks. Delay of gratification originated from developmental and personality psychology as compared to delay discounting, which emerged from behavioral analysis. However, these delay of gratification and delay discounting tasks are largely treated as measuring equivalent constructs (e.g., Green, Fry, & Myerson, 1994; Johnson & Bickel, 2002; Logue, 1988; Reynolds & Schiffbauer, 2005). The delay-of-gratification paradigm usually involves a scenario in which rewards (often food) are placed in plain view of the participant who can choose their less-preferred reward at any time, or wait a longer amount of time to earn their more preferred reward. In these paradigms, most studies have found that obese children tolerate less delay for food items than non-obese children (Bonato & Boland, 1983; Johnson, Parry, & Drabman, 1978; Lewittes & Israel, 1978; Sigal & Adler, 1976; Sobhany & Rogers, 1985); one study did not find this difference, although there were still differences in the individuals' eating patterns (Geller, Keane, & Scheirer, 1981). Another study found no difference between overweight and

normal-weight girls in their ability to delay gratification, but did find that the overweight girls utilized less-effective self-control strategies during the delay period, a finding that may have implications for one's long-term ability to delay gratification (Bourget & White, 1984).

Impulsivity, and its theoretical counterpart self-control, are the constructs most likely cited when discussing the discounting paradigm. The effect of impulsive traits (as measured by questionnaires) on delay and probabilistic discounting has been found consistently, suggesting that impulsivity is closely related to the discounting process (Ostaszewski & Karzel, 2005). As previously mentioned, impulsivity has been defined as the choice of a smaller, more immediate reward over a larger, more delayed reward, with self-control as the opposite (Rachlin & Green, 1972). Given this definition, it is not surprising that discounting is often conceptualized as the underlying mechanism of behavioral impulsivity and self-control (Logue, 1995; Ostaszewski & Karzel, 2005). The advantage of using this definition is its quantitative nature and ease of translation into a laboratory discounting study. It also provides a synopsis of often-complex choice behavior and can be applied to many behaviors found in nature, including food selection and clinical problems (Logue, 1988). Disadvantages include the possibility that the discounting of more immediate and concrete rewards such as money may not be related to more delayed and abstract rewards such as good health (Rachlin, 2000).

Impulsivity and self-control are concepts quite relevant to a society that views extreme impulsivity/lack of self-control as negative qualities. The colloquial definition of self-control perceives self-control as an inner quality; thus, the Western view of a trim body as evidence of this virtue, and the consequent denigration of obesity, even by obese individuals (Brownell, 1991; Wang, Brownell, & Wadden, 2004). Conversely, the behavioral definition removes the moral connotation of the word that perceives self-control as an inner quality, and instead views self-control as a direct result of how

sensitive one's behavior is to the effect of delay and amount (Green & Myerson, 1993; Logue, Rodriguez, Peña-Correal, & Mauro, 1984). Humans have evolved in accordance with the principle that the longer an event is delayed, the less likely the event will occur. Delayed reinforcers are therefore "discounted" in value because of the lower probability of receiving the reinforcer. Indeed, two recent studies found that uncertainty ratings were moderately correlated (r = .55 and .37, respectively) with the delay discounting task, implying that delayed rewards can equal "uncertain" in people's minds (Patak & Reynolds, 2007; Reynolds, Patak, & Shroff, 2007). Thus, waiting for food can be risky in evolutionary terms; unreliable food resources and energy expended in obtaining food suggests that the optimal choice may be to seek out immediate rewards and eat when food is available (Logue, 2004). In sum, "The future is uncertain; eat dessert first" (Fantino, 1995). Although impulsivity has been advantageous in the past, the predictability and availability of food for most humans in today's environment means that discounting delayed rewards and choosing to eat now can be maladaptive and potentially may lead to obesity (Ainslie, 1992; Wadden, Brownell, & Foster, 2002). It is possible that our reward systems and self-control interact to produce our decisions about food (van den Bos & de Ridder, 2006).

It is not therefore surprising that individuals exhibit less self-control for food reinforcers delivered immediately within a session than for points exchangeable for food at the end of a session (Forzano & Logue, 1994). However, it is not clear whether this finding reflects a general property of consumable rewards, or whether it represents something special about the food (Odum & Rainaud, 2003). An 'abused' substance, such as food or drugs, might be discounted more steeply than money because it is an immediately reinforcing reward, whereas money is a conditioned reinforcer. In other words, differences in the time of delivery between rewards may help determine whether one acts 'impulsively' or with self-control (Logue, King, Chavarro, & Volpe, 1990).

Conversely, it may be that 'abused' substances, that is, substances with the potential to be used in excess of what is beneficial in the long-term, may be discounted more steeply because the individual truly values this substance more than money, or because there is something special about the abused substance.

The 'problem' of self-control and choice behavior is that individuals can only act in the present (Mischel, 1984; Rachlin, 2000). Viewing two alternatives at a distance, one can be objective in evaluating their relative value; however, when the smaller reward is "virtually dangled in front of our noses," desire for it is elevated and, unless contingencies are in place, it is easy to make the impulsive choice (Rachlin, 2000). With simple ambivalence and two clearly defined alternatives, self-control is often easier; for example, the choice between one candy now versus two candies in an hour. Complex ambivalence involves a smaller, more immediate and distinct reward versus a larger, abstract reward; for example, abstaining from the ice-cream sundae now for better health later. Better health in the future is certainly preferred to one sundae now, but the sundae is often chosen because 'better health' is distant in time, abstract, not clearly definable or measurable, and not even certain (Logue, 1995). The serious self-control/impulsive problems of everyday life usually arise as complex ambivalence (Rachlin, 2000).

Substance Abuse

People frequently engage in short-term behaviors counter to their overall best interest (Rachlin, 2000). Theoretically, delay discounting can be used to analyze almost any behavior that involves delayed consequences that aggregate over time (Critchfield & Kollins, 2001). Behavioral problems such as substance abuse, gambling, and overeating, which involve a discrepancy between global long-term outcomes and specific short-term choices, can be examined within a discounting paradigm. Applying this paradigm to issues of clinical relevance, however, is still in its nascent stages. One

study found that individuals with schizophrenia discount more steeply than controls (Heerey, Robinson, McMahon, & Gold, 2007), another study examined discounting among individuals with high and low social anxiety (Rounds, Beck, & Grant, 2007), and several studies have found that individuals with ADHD discount delayed monetary rewards more steeply than controls (Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001; Schweitzer & Sulzer-Azaroff, 1995; Solanto, Abikoff, & Sonuga-Barke, 2001; Sonuga-Barke, Taylor, Sembi, & Smith, 1992; Sonuga-Barke, Williams, Hall, & Saxton, 1996; Winstanley, Eagle, & Robbins, 2006), but the vast majority of studies examining discounting tasks within a clinical population have focused on substance abusers (Reynolds, 2006b).

Participants who abuse alcohol, nicotine, cocaine, methamphetamines, and opioids have consistently been found to discount delayed rewards more steeply than controls (with crack users discounting more steeply than heroin users; Bornovalova, Daughters, Hernandez, Richards, & Lejuez, 2005), and to discount their abused substance more steeply than money (Ainslie & Haendel, 1983; Baker, Johnson, & Bickel, 2003; Bickel, Odum, & Madden, 1999; Bjork, Hommer, Grant, & Danube, 2004; Bretteville-Jensen, 1999; Chesson & Viscusi, 2000; Coffey, Gudleski, Saladin, & Brady, 2003; Critchfield & Kollins, 2001; Field, Rush, Cole, & Goudie, 2007; Giordano et al., 2002; Heil, Johnson, Higgins, & Bickel, 2006; Hoffman et al., 2006; Kirby & Petry, 2004; Kirby, Petry, & Bickel, 1999; Madden, Bickel, & Jacobs, 1999; Madden, Petry, Badger, & Bickel, 1997; Mitchell, Fields, D'Esposito, & Boettiger, 2005; Mitchell, 1999; Odum, Madden, Badger, & Bickel, 2000; Odum, Madden, & Bickel, 2002; Odum & Rainaud, 2003; Petry, 2001a, 2002, 2003; Reynolds, 2006a; Reynolds, Karraker, Horn, & Richards, 2003; Reynolds et al., 2007; Vuchinich & Simpson, 1998; Yi, Chase, & Bickel, 2007). One study found that sober undergraduates actually discounted delayed rewards at a steeper rate than intoxicated undergraduates (Ortner, MacDonald, & Olmstead,

2003), but a recent study using a more sensitive measure of discounting did find that alcohol at two different levels promoted steeper discounting compared to placebo (Reynolds, Richards, & de Wit, 2006).

Further, notable differences have been found among subgroups of substance abusers with comorbidity that support discounting's face validity, divergent validity, and sensitivity to measure comorbidity. For example, substance abusers with gambling problems show steeper discount rates than substance abusers without gambling problems (Petry & Casarella, 1999); gamblers with substance abuse comorbidity show steeper discount rates than gamblers without substance abuse comorbidity (Petry, 2001b); and substance abusers with antisocial personality disorder show steeper discount rates than substance abusers without antisocial personality disorder (Petry, 2002). However, one study found that alcoholics with cluster B personality disorder did not differ on delay discounting from alcoholics without cluster B personality disorder (Dom, De Wilde, Hulstijn, Van Den Brink, & Sabbe, 2006). Notwithstanding the few divergent findings, individuals who abuse more alcohol (Field, Christiansen, Cole, & Goudie, 2007; Vuchinich & Simpson, 1998), more nicotine (Heyman & Gibb, 2006; Ohmura, Takahashi, & Kitamura, 2005), or become alcoholic earlier in life (Dom, D'haene, Hulstijn, & Sabbe, 2006) show steeper discount rates than less-frequent abusers, or later-onset abusers (although one study found no difference between light and heavy smokers; Johnson, Bickel, & Baker, 2007). Studies of probability discounting between smokers and nonsmokers have had mixed results, likely because an effect is only seen when heavy smokers are compared against nonsmokers (Yi, Chase, & Bickel, 2007). The discounting tasks have been applicable to assessing substance abusers, but they also have been applicable to other behavioral problems such as gambling (Alessi & Petry, 2003; Dixon, Jacobs, & Sanders, 2006; Dixon, Marley, & Jacobs, 2003; Holt, Green, & Myerson, 2003; MacKillop, Anderson, Castelda, Mattson, & Donovick, 2006).

Discounting rates also may be malleable, as studies have found that current substance abusers show steeper discount rates than abstinent former substance abusers, who, in turn, show steeper discount rates than never-substance-abusers (Baker, Johnson, & Bickel, 2003; Bickel, Odum, & Madden, 1999; Bretteville-Jensen, 1999; Kirby & Petry, 2004; Odum, Madden, & Bickel, 2002; Petry, 2001a). A study of college students without substance abuse disorders found that the degree of discounting and the age of first alcohol use, smoking, marijuana use, and total number of substances used were significantly correlated (Kollins, 2003). These results demonstrate ecological validity of discounting as a measure of impulsivity, noting a clear differentiation that exists between substance abusers and lower-level or abstinent abusers.

Recently, investigators have examined the effect of drug deprivation on discounting rates, with mixed results. One study found that nicotine deprivation led to steeper discounting for both cigarette and monetary rewards (Field, Santarcangelo, Sumnall, Goudie, & Cole, 2006), while another study found that nicotine deprivation led to steeper discounting for cigarette, but not monetary rewards (Mitchell, 2004), and a study on cocaine deprivation found no difference between abstinent and current users (Heil, Johnson, Higgins, & Bickel, 2006).

Questionnaire-measured impulsivity has been found to predict substance abuse (Dawes, Tarter, & Kirisci, 1997) and gambling (Vitaro, Arseneault, & Tremblay, 1999), and reliable negative correlations have been found between discount rates and college grade-point averages (Kirby, Winston, & Sentiesteban, 2005). Only recently, however, have studies on the predictive validity of discounting been conducted. One study examined delay discounting rates among adolescents who had completed a smoking cessation program – abstinent adolescents discounted less steeply on a real-time discounting task, but not on a questionnaire measure of discounting (Krishnan-Sarin et al., 2007). This was consistent with a study that found individuals who smoked after a 3-

hour deprivation period showed steeper discounting than individuals who continued to abstain (Dallery & Raiff, 2007). Another study examined delay discounting at baseline among pregnant smokers who had spontaneously quit, and found that delay discounting significantly predicted relapse to smoking status at 24 weeks postpartum, with steeper discounting indicating less likelihood of postpartum abstinence (Yoon et al., 2007). Further, delay discounting had been assessed periodically throughout their partum and postpartum periods and did not significantly change over time regardless of smoking relapse status, a stability also found in an examination of abstinent inpatient alcoholics (Takahashi, Furukawa, Miyakawa, Maesato, & Higuchi, 2007).

A few studies have examined clinical implications of discounting and substance abuse. One study found that, surprisingly, smoking cues (e.g., holding a cigarette) had no effect on delay discounting in smokers (Field, Rush, Cole, & Goudie, 2007); another recent study may explicate these reasons. Audrain-McGovern and colleagues followed a cohort of adolescents for four years. They found that delay discounting was significantly correlated with baseline smoking rates, but only indirectly influenced the odds of smoking progression via its impact on complementary reinforcers (i.e., accompanying activities that reinforce smoking such as alcohol use and peer smoking). The authors suggest that delay discounting may indirectly influence smoking development, but directly affect smoking behavior once the habit is established (Audrain-McGovern et al., 2004). These results suggest either a premorbid difference in impulsivity and ability to delay gratification that leads to substance abuse, a direct effect of the drug that affects discounting rates, or improved self-control once the behavior improves (Kirby & Petry, 2004). Further longitudinal studies are needed to assess the direction of causality between discounting rates and impulsive behavior. In sum, the literature suggests that substance abusers discount money more steeply than controls, discount their abused substance more steeply than money, produce steeper discount

rates if they have a comorbid diagnosis, generate steeper discount rates if they are a current user instead of an abstinent user, and have discount rates that are predictive of their nicotine abstinence status.

Although substance abusers discount their abused substance more steeply than money, it is not clear whether this indicates a unique feature about the abused substance or the substance abuser, or whether it might represent a general property of immediately consumable rewards (Odum & Rainaud, 2003). In support of the latter possibility, nonalcoholics were shown to discount alcohol more steeply than money (Petry, 2001a), and non-alcoholics were found to discount alcohol and food equally but more steeply than money (Odum & Rainaud, 2003). Recently, Estle et al. (2007) recruited non-substance-abusing college students to study delay and probabilistic discounting in comparing an abused substance (alcohol) with non-abused but immediately consumable substances (beer, soda, and candy). They found that, for both smaller and larger amounts, participants discounted delayed monetary rewards less steeply than directly consumable rewards (beer, candy, soda), which were discounted at equivalent rates. These results support the idea that money may be discounted less steeply than consumable rewards because money retains its value and is exchangeable for other goods, whereas consumable rewards such as alcohol or food are most valuable at the moment of discounting (Catania, 1998; Odum, Baumann, & Rimington, 2006). Estle and colleagues also found, however, that among probabilistic rewards, there was no difference between the discounting of monetary and directly consumable rewards. Thus far, no study has examined the discounting of abused substances compared to other immediately consumable rewards in a clinical population.

Health Domains

Discounting of health decisions has not been examined as thoroughly as the discounting of monetary amounts, but the findings to date demonstrate that decisions

regarding both health and money show delay, magnitude, and sign effects, with the effect of the latter two factors appearing more pronounced for health than for money (Chapman, 1996; Chapman & Elstein, 1995; Rose & Weeks, 1988). Another outcome from these studies has been the consistency with which domain independence was demonstrated (Cairns, 1992; Chapman, 1996; Chapman & Elstein, 1995; Chapman, Nelson, & Hier, 1999; Fuchs, 1982; Petry, 2003). Domain independence is the finding that individuals produce reliable discount rates *within* a domain, but low correlations *between* domains, such as that between health and money. Domain independence is contrary to discounted utility theory, which states that the same delay discount rate should be applied to all outcomes if goods are indeed exchangeable (Chapman, 1996; Loewenstein & Prelec, 1992). Instead, individuals tend to have different discount rates for different domains. For example, vacation time and health were discounted more similarly, and more steeply, than money (Chapman & Elstein, 1995), and this was not accounted for by participant familiarity with the domains, nor in dissimilarities between descriptions of the domains (Chapman, Nelson, & Hier, 1999). Domain independence is posited to result from the immediacy with which one must enjoy health or a vacation (primary reinforcers), whereas money can be borrowed, invested, and exchanged for rewards (conditioned reinforcer; Chapman, Nelson, & Hier, 1999).

Rationale for Clinical Use

The discounting model of impulsivity and self-control predicts that discounting rates would be correlated with impulsive behavior in the real world (Ainslie, 1975; Rachlin, 2000). Indeed, group differences in the discounting tasks noted between substance abusers and controls (e.g., Madden, Petry, Badger, & Bickel, 1997), levels of substance abuse (e.g., Petry, 2001a), high- and low-risk psychiatric outpatients (Crean, de Wit, & Richards, 2000), borderline personality disorder and controls (Dougherty, Bjorka, Huckabee, Moellera, & Swanna, 1999), extraverts and introverts (Ostaszewski,

1997), and age cohorts (Green, Fry, & Myerson, 1994) offers a degree of face validity that performance on the discounting tasks measures at least one dimension of impulsivity, or a mechanism or trait highly correlated with impulsive behavior (Kirby, Petry, & Bickel, 1999). It is possible, then, that individual differences in discounting may play a factor in determining to which group (e.g., substance abusers or not) an individual will belong (Green & Myerson, 2004), with special populations distinguished in terms of discounting (Critchfield & Kollins, 2001). Discounting provides a precise, quantitative approach for studying behavior in the lab (Crean, de Wit, & Richards, 2000) that has been found to be relatively stable over time (Simpson & Vuchinich, 2000; Takahashi, Furukawa, Miyakawa, Maesato, & Higuchi, 2007).

Behavioral problems including aggression, gambling, depression, overeating, and failure to exercise have all been postulated to involve some amount of impulsivity (Bickel & Marsch, 2001). Even though a subset of binge eaters has demonstrated stronger correlations with impulsivity measures than with dietary restraint (Steiger, Lehoux, & Gauvin, 1999), and 25% of one sample of successful weight losers cited future health concerns as motivation to lose weight (Tinker & Tucker, 1997), discounting tasks have never been utilized in a sample of overweight or eating-disordered individuals. Examining behavioral characteristics with discounting tasks is a more construct-relevant indicator of impulsivity than questionnaires (Petry, 2001b), which, by their very nature, are not a direct measure of behavior (Epstein, 1992). Discounting tasks also enable examination of the behavioral process in a way that allows experimental analysis (Bickel & Marsch, 2001). Using discounting measures in this population may foster a better understanding of the nuances in maladaptive impulsive behavior such as binge eating. Ultimately, these findings may lead to distinguishing subtypes, predicting future behavior, and informing individual interventions (Critchfield & Kollins, 2001).

Impulsivity

Multidimensional Definition

Both personality and behavioral researchers tend to use the term 'impulsive' as if it was a unitary construct, but it now is well recognized that the only consensus regarding impulsivity is its multidimensional nature (Crean, de Wit, & Richards, 2000; Evenden, 1999; Helmers, Young, & Pihl, 1995; Reynolds, Ortengren, Richards, & de Wit, 2006; White et al., 1994). Disagreement continues as to the number and type of impulsivity dimensions, which ranges from two (Eysenck, Pearson, Easting, & Allsopp, 1985) to fifteen (Gerbing, Ahadi, & Patton, 1987), and has included such various concepts in the personality literature as an inability to wait, insensitivity to consequences, tendency to act without forethought, novelty-seeking, and an inability to inhibit inappropriate behaviors (Ainslie, 1975; Barkley, 1997; Barratt & Patton, 1983; Cloninger, 1987; Eysenck, 1993; Rachlin & Green, 1972). The behavioral definition, as discussed earlier, states that impulsivity is the choice of a smaller, more immediate reward over a larger, more delayed reward (Ainslie, 1975; Logue, 1988; Rachlin, 1995); both personality and behavioral definitions associate impulsivity with a preference for more immediate gratification (Mitchell, 1999).

Additional support for the multidimensionality nature of impulsivity appears in the numerous factor-analytic studies that have produced several possible components of impulsivity. For example, Barratt derived the factors motor impulsiveness, nonplanning impulsiveness, and attentional impulsiveness for the eleventh revision of his Barratt Impulsiveness Scale questionnaire (Barratt, 1994). The multifactorial nature of impulsivity also is evident in examining the variety of some of the psychiatric disorders most associated with "impulsive" behavior in the DSM-IV nosological system: substance abuse disorders, mania, personality disorders, and attention-deficit/hyperactive disorder (American Psychiatric Association, 1994; Evenden, 1999). Further, behavioral

measures that purport to measure motor impulsivity or inhibitory control deficits have not correlated highly with discounting tasks (de Wit, Enggasser, & Richards, 2002; Reynolds, Richards, & de Wit, 2006), and often find different results than discounting tasks (Acheson, Reynolds, Richards, & de Wit, 2006; Bornovalova, Daughters, Hernandez, Richards, & Lejuez, 2005; Crean, Richards, & de Wit, 2002; Reynolds et al., 2007). Finally, the positive correlation observed between delay and probabilistic discounting tasks, where a negative correlation would indicate the same underlying process, and the domain independence between constructs such as money and health, argues against a unitary impulsivity construct (Green & Myerson, 2004).

Correlation between Discounting Tasks and Questionnaires

Individuals demonstrating impulsive behavior such as substance abuse, gambling, aggressive behavior, and trichotillomania have scored higher on impulsivity questionnaires than controls (Barratt, 1994; Carlton & Manowitz, 1994; Kennedy & Grubin, 1990; McCown, 1989; Stein, Islam, Cohen, DeCaria, & Hollander, 1995). Additionally, self-report impulsivity questionnaires (e.g., BIS-11, I-7) usually are correlated with each other (Dolan & Fullam, 2004; Gerbing, Ahadi, & Patton, 1987; Lane, Cherek, Rhoades, Pietras, & Tcheremissine, 2003; Reynolds, Ortengren, Richards, & de Wit, 2006).

For the fewer number of studies that have used both self-report questionnaires and behavioral measures such as discounting, equivocal findings have been found in the correlation between these two types of measurements. Some studies have found moderate correlations between self-report questionnaires (or specific subscales) and discounting (Bjork, Hommer, Grant, & Danube, 2004; Heyman & Gibb, 2006; Kirby, Petry, & Bickel, 1999; Madden, Petry, Badger, & Bickel, 1997; Mitchell, Fields, D'Esposito, & Boettiger, 2005; Mobini, Grant, Kass, & Yeomans, 2007; Reynolds, Richards, & de Wit, 2006; Richards, Zhang, Mitchell, & de Wit, 1999; Swann, Bjork,

Moeller, & Dougherty, 2002), but most studies have found low, or no, correlations between these measures (Crean, de Wit, & Richards, 2000; Crean, Richards, & de Wit, 2002; de Wit, Enggasser, & Richards, 2002; Dom, De Wilde, Hulstijn, Van Den Brink, & Sabbe, 2006; Gerbing, Ahadi, & Patton, 1987; Kirby & Petry, 2004; Lane, Cherek, Rhoades, Pietras, & Tcheremissine, 2003; Mitchell, 1999; Ortner, MacDonald, & Olmstead, 2003; Reynolds, Ortengren, Richards, & de Wit, 2006; Reynolds, Richards, Horn, & Karraker, 2004; White et al., 1994). For the studies that have demonstrated correlations, the correlations have, for the most part, been in the expected direction (e.g., Coffey, Gudleski, Saladin, & Brady, 2003). For example, Richards et al. (1999) found that individuals with the steepest discounting rates also scored highest on personality measures of impulsivity. The authors noted that this was more remarkable given the fact that few of the questions on the personality tests actually referred to the discounting of future consequences. Mitchell (1999) also notes that what appears as a problematic weak relationship between self-report and behavioral measures of impulsivity is actually intuitive when considering that different scales of personality questionnaires have been developed to specifically measure different components of impulsivity, and these scales have been developed to be independent of the other scales on the same questionnaire. Thus, expectations of a strong relationship between any questionnaire and behavioral tasks of impulsivity may be too lofty given the multidimensional nature of impulsivity.

Further research has examined whether self-report and behavioral measures are measuring the same constructs. Along with finding no correlation between self-report and behavioral tasks, a principal-components analysis of the behavioral tasks determined that they appeared to measure either “impulsive disinhibition” or “impulsive decision-making;” the delay discounting task fell into the latter category (Reynolds, Ortengren, Richards, & de Wit, 2006). Other studies also have concluded that the ability

to inhibit responses is not correlated with the ability to delay rewards (Lane, Cherek, Rhoades, Pietras, & Tcheremissine, 2003; Sonuga-Barke, 2002; Swann, Bjork, Moeller, & Dougherty, 2002). Thus, both self-report questionnaires and behavioral measures may be multifactorial, measuring different components of impulsivity.

Another viewpoint holds that discounting tasks may instead be conceptualized as an index of impulsivity or a mechanism behind impulsivity, rather than as an assessment of the construct of impulsivity, as questionnaire measures attempt to do (Baker, Johnson, & Bickel, 2003). In other words, discounting tasks may provide a more comprehensive, construct-relevant indicator of impulsivity than do trait measures because of their ability to describe specific preferences depending on the commodities used, for example, and whether the decision point is phrased as a gain or a loss (Baker, Johnson, & Bickel, 2003; Petry, 2001b).

Regardless, it is clear that the psychometrics of impulsivity is in need of further research. Exploring the relationship between self-report and behavioral measures of impulsivity would not only aid the theoretical discussion of the components of impulsivity, but also may suggest what discounting tasks measure specifically. Furthermore, even if this relationship is not explicated fully, using these measures both in specific clinical groups as well as in the general population and measuring their predictive validity for future behavior will likely remain a priority area of research (Green & Myerson, 2004; Mitchell, 1999).

Impulsivity and Binge Eating

Introduction

Eating and weight disorders provide a suitable opportunity for examining behavioral choices involving impulsivity. In order to establish habits that are easier to follow, and to delineate a 'right' from a 'wrong' choice, individuals often perceive choices as setting precedents for their future choices. Although this system may work well for

choices such as whether or not to abuse drugs, or whether or not to gamble, it appears to work less well for the continuous judgments necessary in areas of complex ambivalence, such as choosing food (Ainslie, 2001; Rachlin, 2000). Viewing a lapse in one's diet as a precedent for future choices can reduce one's hope for future self-control, a dichotomous thinking style that characterizes many individuals who regain their lost weight, as well as for binge eaters (Ainslie, 2001; Byrne, Cooper, & Fairburn, 2003; Cohen & Petrie, 2005). Additionally, food choices mirror discounting choices when considering either healthy foods now to maximize future health at the expense of current taste, or choosing unhealthy foods now to maximize current taste at the expense of future health.

In a less theoretical and more experimental realm, self-report measures of impulsivity have been found to predict food intake in normal-weight women (Guerrieri, Nederkoorn, & Jansen, 2007; Guerrieri et al., 2007), and poor treatment outcome in anorectic women (Fichter, Quadflieg, & Hedlund, 2006). Further, the urgency subscale of the UPPS questionnaire predicted bulimic symptomatology in one study (Anestis, Selby, & Joiner, 2007), and another study found women who had elevated scores on the disinhibition scale of the Three Factor Eating Questionnaire also had elevated scores on questionnaire and behavioral measures of impulsivity (BIS-11 and delay discounting task, respectively; Yeomans, Leitch, & Mobini, 2008).

Binge eating, a hallmark feature of bulimia nervosa and binge eating disorder (BED), involves a sense of loss of control over what one is eating (American Psychiatric Association, 1994). Because binge eating is considered an impulsive behavior, much research has examined the connection between impulsivity and eating disorders, especially eating disorders that involve binge eating. However, no studies have used behavioral tasks such as discounting that could examine impulsivity in decision-making in this population.

Individuals who binge eat have been shown to have higher rates of Cluster B personality disorders (e.g., borderline, histrionic, narcissistic) with their accompanying traits of impulsivity and interpersonal instability (Grilo, 2002; Herzog, Keller, Lavori, Kenny, & Sacks, 1992; Karwautz, Troop, Rabe-Hesketh, Collier, & Treasure, 2003; Mitchell & Mussell, 1995; O'Brien & Vincent, 2003; Steiger, Thibaudeau, Ghadirian, & Houle, 1992). Some studies suggest that eating disordered individuals with personality disorders have greater psychopathology but no worse eating disorder symptoms (Fahy & Eisler, 1993; Grilo et al., 2003; Johnson, Tobin, & Dennis, 1990; Steiger, Thibaudeau, Leung, Houle, & Ghadirian, 1994; Wolfe, Jimerson, & Levine, 1994; Wonderlich & Swift, 1990), whereas others suggest that personality pathology (especially Cluster B traits and impulsivity) is associated with more severe binge eating (Bruce & Steiger, 2005; Favaro et al., 2005; Newton, Freeman, & Munro, 1993; Stice et al., 2001; Wilfley et al., 2000). One seminal study of 709 women with eating disorders found that of the 118 women diagnosed with an impulse-control disorder, all but three engaged in binge eating, and those 115 individuals had more severe eating disorders and greater general psychopathology than the women with an eating disorder who did not have an impulse-control disorder (Fernandez-Aranda et al., 2008). As with other personality constructs, impulsivity has been shown to vary among individuals and across diagnostic categories (Cassin & von Ranson, 2005; Strober, 1983; Vitousek & Manke, 1994), but it remains to be seen whether consistent group patterns would be found when modeling behavior on discounting tasks.

Bulimia Nervosa

Research has found consistently that individuals with bulimia nervosa score higher on impulsivity self-report measures than both individuals without bulimia nervosa (Cassin & von Ranson, 2005; Claes, Vandereycken, & Vertommen, 2002; Kane, Loxton, Staiger, & Dawe, 2004; Newton, Freeman, & Munro, 1993; Rosval et al., 2006; Steiger

et al., 2004; Steiger et al., 2001; Wolfe, Jimerson, & Levine, 1994) and individuals with restricting anorexia nervosa (Cassin & von Ranson, 2005; Claes, Vandereycken, & Vertommen, 2002; Fahy & Eisler, 1993; Rosval et al., 2006; Vervaet, van Heeringen, & Audenaert, 2004), but these studies did not use psychiatric controls, nor did they control for other impulsive behaviors. One study that used community samples of women with either lifetime substance abuse, affective disorder, bulimia nervosa, or no psychopathology found similar rates of self-report impulsivity among these groups; however, it also reported that women with more than one disorder were more impulsive than women with just one of these disorders (Bushnell, Wells, & Oakley-Browne, 1996). Another study using factor analysis determined that among individuals with bulimia nervosa or bulimic pathology, having both high impulsivity *and* compulsivity produced more impairment on eating disorder and depressive indices than elevated scores on either dimension alone (Engel et al., 2005). Several other cluster analytic studies have found evidence for three classes of bulimic individuals, one of which is an "impulsive" class (Goldner, Srikameswaran, Schroeder, Livesley, & Birmingham, 1999; Strober, 1983; Westen & Harnden-Fischer, 2001; Wonderlich et al., 2005), and another latent class analysis study found a two-class characterization of bulimia nervosa, one with several markers of impulsivity such as substance use and antisocial behavior (Duncan et al., 2005).

Based on Lacey and Evans' (1986) proposition that a "multi-impulsive" subgroup of bulimics exist with poorer treatment prognosis, later studies further examined this phenomenon. Approximately half of two other bulimia nervosa samples met criteria for Lacey's multi-impulsive bulimia nervosa (Fahy & Eisler, 1993; Newton, Freeman, & Munro, 1993), although the amount of impulsivity did not discriminate treatment response at follow-up (Fahy & Eisler, 1993). Latent class analyses further supported this clinical classification of a multi-impulsive subtype of bulimia nervosa (Myers et al.,

2006). In a review of the prevalence of alcohol use disorders in bulimia nervosa, the median prevalence of alcohol abuse or dependence was calculated as 22.9% (Bulik et al., 2004; Holderness, Brooks-Gunn, & Warren, 1994), and bulimics with comorbid alcohol abuse were found to score higher on impulsivity measures than bulimics without alcohol abuse (Kane, Loxton, Staiger, & Dawe, 2004). Another study found that women with bulimia nervosa plus a lifetime impulse-control disorder scored higher on novelty seeking and impulsivity indices, and general psychopathology, than women with bulimia nervosa without an impulse-control disorder (Fernandez-Aranda et al., 2006). Thus, the literature suggests that individuals with bulimia nervosa are more impulsive than controls, but may only be more impulsive than other psychiatric controls in the presence of comorbid substance abuse or impulse-control disorder.

Even if individuals with bulimia nervosa are indeed more impulsive than other eating disordered individuals, it is not clear that impulsivity negatively impacts treatment prognosis (Keel & Mitchell, 1997). A number of studies have found a positive correlation between baseline impulsivity problems and poor treatment outcome (Fichter, Quadflieg, & Rief, 1994; Johnson-Sabine, Reiss, & Dayson, 1992; Keel, Mitchell, Miller, Davis, & Crow, 2000; Rossiter, Agras, Telch, & Schneider, 1993; Sohlberg, Norring, Holmgren, & Rosmark, 1989; Vaz, 1998), or between impulsivity and premature discontinuation of therapy (Agras et al., 2000), whereas others have found no relation between impulsivity and eating disorder outcome (Edelstein, Yager, Gitlin, & Landsverk, 1989; Fahy & Eisler, 1993; Wonderlich, Fullerton, Swift, & Klein, 1994), or even a relation between baseline impulsivity scores and a favorable response to treatment (Fassino et al., 2005). However, most studies reviewed suggest that impulse-control problems predict a poorer treatment outcome for women diagnosed with bulimia nervosa (National Institute for Clinical Excellence, 2004; Keel & Mitchell, 1997), even if this poorer outcome is in

regards to comorbid psychiatric functioning rather than the course of the eating disorder (Bruce & Steiger, 2005; Grilo, 2002).

A poorer response to treatment makes intuitive sense when reviewing studies that show two mechanisms underlying the development of bulimia nervosa: dietary restraint and disinhibition/affective instability (Steiger, Lehoux, & Gauvin, 1999; Vitousek & Manke, 1994). If treatment is focused on normalizing dietary restraint, it would appear that this would be less effective for those who have more problems with impulsivity (Vervaet, van Heeringen, & Audenaert, 2004). Finally, it may be that impulsivity in eating disorders are more state-dependent (i.e., reliant on the eating disorder symptoms) than trait-dependent given that impulsivity has appeared to improve following recovery from bulimia nervosa (Ames-Frankel et al., 1992).

Binge Eating Disorder and Obesity

Much less research has examined the relationship between impulsivity and either BED or obesity, even though the clinical DSM-IV definition of BED includes a number of criteria that could be considered impulsive, such as lack of control over eating (Cassin & von Ranson, 2005; Nasser, Gluck, & Geliebter, 2004). Within individuals diagnosed with BED, prevalence rates of borderline personality disorder (characterized by impulsive traits) have been shown to be approximately 9% on average, compared to approximately 1% in the general population (Telch & Stice, 1998; van Hanswijick de Jonge, van Furth, Lacey, & Waller, 2003; Widiger & Weissman, 1991; Wilfley et al., 2000; Yanovski, Nelson, Dubbert, & Spitzer, 1993); a similar relationship has been found among individuals with ADHD (characterized by impulsive traits) and BED (Cortese, Bernardina, & Mouren, 2007). Impulsive traits found in Cluster B personality disorders also have predicted poorer treatment response in individuals with BED (Stice et al., 2001; Wilfley et al., 2000). Individuals with BED have been found to be more impulsive than obese individuals without BED (de Zwaan et al., 1994; Fassino et al., 2002; Galanti, Gluck, &

Geliebter, 2007; Nasser, Gluck, & Geliebter, 2004; van Hanswijick de Jonge, van Furth, Lacey, & Waller, 2003), more impulsive than obese individuals with subthreshold BED (Nasser, Gluck, & Geliebter, 2004), and to engage in binge eating more impulsively (versus obsessing beforehand) than individuals with bulimia nervosa (Raymond et al., 1999). Further, one study found impulsivity scores to be positively correlated with BED criteria (e.g., 'loss of control during a binge', 'eating when not physically hungry'; Nasser, Gluck, & Geliebter, 2004), and another study found impulsivity to be the greatest predictor of test meal intake, accounting for 16% of the variance (Galanti, Gluck, & Geliebter, 2007). However, one study did not find obese individuals with BED to differ on impulsivity compared to nonbinging obese (Davis, Levitan, Carter et al., 2007). Another study found that individuals with BED who had a lifetime diagnosis of alcohol or drug abuse or dependence were more impulsive than individuals with BED without this comorbidity (Peterson, Miller, Crow, Thuras, & Mitchell, 2005). In sum, the majority of questionnaire-based research states that individuals with BED are more impulsive than obese individuals without BED, and that these impulsive traits may impact food intake and the behavioral characteristics of BED. Table 1 provides a summary of the studies on BED and impulsivity.

Table 1.

Binge Eating Disorder Studies on Impulsivity

Study	Subjects	Impulsivity Measure	Results
de Zwaan et al., 1994	43 BED, 20 BE, 15 OE (all obese)	Multidimensional Personality Questionnaire*	BED sig. more impulsive than BE and OE.
Raymond et al., 1999	31 BN, 39 BED	Binge Eating Behavior Questionnaire**	BN binge eating behavior more obsessive (vs. impulsive) than BED.
Fassino et al., 2002	59 BED, 61 non-BED, 80 controls	Temperament and Character Inventory	BED and non-BED obese sig. more impulsive than control.
Nasser et al., 2004	11 BED, 11 BE, 11 obese controls	Barratt Impulsivity Scale-11	BED sig. higher motor impulsivity (but not cognitive or non-planning) than controls. BIS correlated with severity of binge traits.
Peterson et al., 2005	84 BED	Multidimensional Personality Questionnaire*	BED with lifetime history of alcohol or drug abuse/dependence more impulsive than BED without history.
Galanti et al., 2007	22 BED, 21 BE, 36 obese controls	Barratt Impulsivity Scale-11	BED and BE sig. more impulsive than non-BED. Test meal intake correlated with BIS.
Davis et al., 2007	53 BED, 52 obese, 59 controls	Barratt Impulsivity Scale-11	BED and Obese not sig. different, but more impulsive than normal-weight controls.

BED: Binge Eating Disorder; BE: Binge Eater; OE: Overeater (no loss of control); BN: Bulimia Nervosa
Sig: significantly; * Tellegen, 1985; ** Raymond & Christensen, 1999

The association between impulsivity and obesity also has been examined. Some studies have found obese individuals with or without binge eating to be more impulsive than normal-weight healthy controls when measured by questionnaire (Davis, Levitan, Carter et al., 2007; Faith, Flint, Fairburn, Goodwin, & Allison, 2001; Fassino et al., 2002; Ryden et al., 2004) or behaviorally (Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006). A review of borderline personality disorder and obesity found increased rates of borderline personality disorder only in obese individuals seeking psychological care, or in those who had BED (Sansone, Wiederman, & Sansone, 2000). Several smaller studies have found greater impulsivity to be associated with less weight loss (Bjorvell, Edman, & Schalling, 1989; Jonsson, Bjorvell, Levander, & Rossner, 1986) or high treatment attrition (Bjorvell & Edman, 1989), but two other studies using the same impulsivity measure did not find a relation between impulsivity and 1-year weight-loss relapse status (Bjorvell, Aly, Langius, & Nordstrom, 1994; Poston et al., 1999). The authors suggest that, although impulsivity may not predict weight outcome, it is still likely that it may predict intermediate health behaviors that act as mediators of weight outcome. Another larger-scale study found a questionnaire measure of impulsivity to be unchanged at the 2-year follow-up of a weight loss intervention in severely obese individuals (Ryden et al., 2004). Thus, impulsivity as it is associated with BED and obesity is in need of further study to better determine the mechanisms by which these conditions arise and are maintained.

Clinical Implications

As mentioned previously, discounting measures have the potential to assess a variety of clinical populations in which impulsive choices are a source of distress (Critchfield & Kollins, 2001). If various clinical populations are found to differ in the way they discount rewards, then discounting could be used to distinguish populations. Differences in impulsivity also may vary in a way that affects the etiology or maintenance

of these disorders, with consequent implications for treatment interventions, as well as the role of discounting as an outcome measure (Bickel & Marsch, 2001; Critchfield & Kollins, 2001; Kirby & Petry, 2004). Further, results from behavioral discounting procedures may increase our understanding of impulsivity by facilitating analyses of the variables affecting discounting and the behavioral process that results in impulsivity and loss of control (Bickel & Marsch, 2001). If discounting is found to distinguish populations, with the indicated need for tailored interventions, then interventions for increasing self-control (and thus decreasing impulsivity) may be used in this venture.

For example, external controls put into place by precommitment strategies can work to lessen the chance of an impulsive decision by a vulnerable individual. As a classic illustration, Odysseus was able to successfully resist the call of the Sirens by ordering his crew to tie him to his mast (Ainslie, 1975). Other precommitment strategies include irrevocable contracts and compulsory savings plans made at an earlier timepoint in order to make it difficult or impossible to change one's mind at a later timepoint (Ainslie, 1975; Rachlin, 1989). Another strategy, borrowed from the delay-of-gratification literature in young children, is the use of self-distraction when waiting for a reward. Being engaged in an alternate activity and focusing on the abstract traits (e.g., the pretzels looks like logs) versus positive traits of the reward (e.g., pretzels taste salty, crunchy), can increase self-control (Ainslie, 1975; Binder, Dixon, & Ghezzi, 2000; Bourget & White, 1984; Eisenberger & Adornetto, 1986; Mischel, 1984; Rachlin, 1989). Another method that has shown effectiveness in substance abuse treatment is that of contingency-management procedures that involve frequent tangible reinforcers (e.g., gift certificates) when the target behavior (e.g., meeting attendance) is demonstrated, and rewards that are withheld if the target behavior does not occur (Bickel, Amass, Higgins, Badger, & Esch, 1997; Dallery & Raiff, 2007; Higgins et al., 1994; Petry, 2000);

contingencies have been found to be more effective than a nicotine patch in sustaining abstinence (Dallery & Raiff, 2007).

Treatment Implications from Discounting

Studies that have used the discounting paradigm with clinical populations (usually substance abusers) have noted that rewards or punishers delayed in time, such as increased health or jail time, are discounted steeply by these populations, and thus may not effectively modify these deleterious behaviors (Giordano et al., 2002; Kirby & Petry, 2004; Kirby, Petry, & Bickel, 1999). Instead, programs that offer immediate, tangible rewards, such as those made available in contingency-management procedures, would better provide alternative reinforcers that compete with the rewarding effects of the negative behavior. The inconsistencies in discounting discussed earlier also provide direction for 'exploiting' these biases so as to create more effective interventions (Chapman & Elstein, 1995). For example, the magnitude effect, that discount rates are less steep for large-magnitude delayed outcomes, suggests that the potential to influence appropriate choice behavior would increase if future health outcomes were viewed as important or large by the individual (Chapman & Elstein, 1995). Similarly, the sign effect, that delayed health losses are discounted more steeply than health gains, implies that supporting preventive behavior by framing choices as affecting future health benefits (e.g., increased health and longevity) may be more effective than framing choices as future health problems (e.g., heart disease, diabetes; Odum, Madden, & Bickel, 2002). Finally, given that impulsivity has been reduced through behavioral training in several populations (Binder, Dixon, & Ghezzi, 2000; Dixon, Rehfeldt, & Randich, 2003; Lieb, Zanarini, Schmahl, Linehan, & Bohus, 2004), it is feasible that novel treatments could be developed that reduce the effect of delay on reinforcer value, or that focus on altering the time perspective of patients in order to lower their discounting rates (Kirby & Petry, 2004; Odum, Madden, & Bickel, 2002).

Relevance to Eating Disorders and Obesity

When an individual decides to lose weight, this decision is not a solitary choice, but a choice that has to be made almost continuously throughout the day in choosing the healthier food or in choosing not to eat more than desired (Reynolds & Schiffbauer, 2005). Indeed, one study found that individuals made an average of 226.7 food - and beverage - related decisions per day, much higher than the average 14.4 decisions these participants estimated (Wansink & Sobal, 2007). When viewed in this manner, it becomes more apparent that eating and weight disorders cannot be viewed separately from the personality characteristics, such as impulsivity, that shape and maintain them (Bruce & Steiger, 2005; Wonderlich & Mitchell, 1997). This may be especially pertinent to the investigation of BED, especially in regard to the impulsivity literature already reviewed. Several studies have shown that dieting is not a necessary condition for binge eating to occur in BED (e.g., Grilo & Masheb, 2000; Spitzer et al., 1992; Spurrell, Wilfley, Tanofsky, & Brownell, 1997). Indeed, an apparent absence of association between dietary control and the urge to binge has been observed in impulsive individuals (Steiger, Lehoux, & Gauvin, 1999; Vervaet, van Heeringen, & Audenaert, 2004). Thus, it may be that the current treatments for binge eating aimed at relaxing dietary restraint may not be as effective as treatments that are aimed at improving self-regulation and impulse-control skills, as a pilot study of dialectical behavior therapy for BED has suggested (Telch, Agras, & Linehan, 2001). Regardless, basic research is needed on the psychological factors influencing choice behavior.

It is not known whether individuals with eating or weight problems ascribe greater value to food and/or sedentary activity than individuals without these problems. Although food is essential for all humans, individual variations exist in the reinforcing value of food (Reiss & Havercamp, 1996). It is not difficult to extend this model of differing reward values and postulate that differences in body weight and success in

obesity and binge-eating treatments may be the result of individual differences in the reinforcing value of food. Subjective reports have shown that overweight and obese adults report a higher value for eating and less enjoyment of non-eating activities than normal-weight individuals (Doell & Hawkins, 1982; Jacobs & Wagner, 1984). In extending this work to delineate the possible distinction between obese and non-obese individuals, Saelens and Epstein (1996) examined the reinforcing value of food in obese versus non-obese women using a concurrent schedule computer task. The obese participants rated food as more reinforcing than sedentary activity compared to the non-obese group. The use of a discounting procedure in the proposed study could similarly help differentiate obese from non-obese, and binge eaters from non-binge eaters, in terms of impulsive behavior, self-control, and the value of rewards such as food. Using the discounting framework in conjunction with self-report measures may lead to indications of the determinants of food choice among obese individuals and/or binge eaters.

AIMS AND HYPOTHESES

I. The first aim of this study is to compare degree of discounting of delayed and probabilistic food (an immediately consumable, potentially 'abused' reinforcer), money (a conditioned reinforcer, nonconsumable, not potentially 'abused'), sedentary activity (an immediately nonconsumable, potentially 'abused' reinforcer), and massage time (an immediately nonconsumable, not potentially 'abused' reinforcer) among women who are: (1) obese binge-eaters diagnosed with BED, (2) obese non-binge-eaters, and (3) normal-weight, non-binge-eaters.

If obese participants (binge-eaters and non-binge-eaters) have a general impulsivity problem, then they should discount food and sedentary activity equally steeply, and more steeply than the non-obese participants. If obese participants find food uniquely reinforcing, then both obese groups should discount food more steeply

than the other immediately consumable rewards, and more steeply than the non-obese participants. For delayed rewards, all groups should discount food significantly more steeply than money (see Estle, Green, Myerson, & Holt, 2007; Odum, Baumann, & Rimington, 2006; Odum & Rainaud, 2003). If delayed money is discounted less steeply than the three other immediate reinforcers in all three groups, such a finding would indicate that it is the *timing* of the reinforcer that is the important variable, and not the content of the reward. For probability discounting, it has previously been found that non-obese participants show little differential effect in the discounting among rewards; it is unclear whether a differential effect in discounting between rewards will be found in this new population, or whether the obese participants will differ from non-obese participants in probability discounting. The differences in discounting among the groups will provide information on the possible impulsivity differences between these groups, and the differences in discounting between the rewards will provide information on the reinforcing value of food versus sedentary activity and money. See Table 2 for an outline of the properties of the rewards.

Table 2.

Properties of Rewards Used

Reward	Immediately Reinforcing	Potential for "abuse"	Consumable
Money			
Food	X	X	X
Sedentary Activity	X	X	
Massage	X		

II. The second aim of this study is to determine whether severity of obesity (as measured by BMI) and/or severity of binge eating (as measured by number of objectively large binges per week) are correlated with the participant's degree of delay and probability discounting. It is expected that, similar to previous studies (Mitchell, Fields, D'Esposito, & Boettiger, 2005; Ohmura, Takahashi, & Kitamura, 2005; Reynolds, 2004), obesity and binge eating severity will be correlated with the degree of discounting delayed rewards, but will not be correlated with the degree of discounting probabilistic rewards, given the previous literature suggests this pattern.

III. The third aim of this study is to determine whether a participant's comorbid general psychopathology, especially comorbid substance abuse, is correlated with the participant's degree of delay and probability discounting. It is hypothesized that comorbidity will be positively correlated with the "immediately consumable" rewards of food, sedentary activity, and massage time.

IV. The fourth aim of this study is to explore convergent and discriminative validity of impulsivity assessments by comparing questionnaire measures of self-control and impulsivity to the behavioral-discounting computerized measure. It is expected that the questionnaire and behavioral measures will be weakly correlated, but in a positive direction.

V. The fifth aim of this study is to evaluate the magnitude effect, determining if the effect of amount on discounting is observed with different types of non-monetary rewards, and within these participant groups. It is expected that larger delayed amounts of rewards will be discounted less steeply than smaller delayed amounts, whereas larger probabilistic rewards will be discounted more steeply than smaller probabilistic rewards.

Significance of Proposed Research

Obesity is an increasingly prevalent health problem in the United States, with 22.3% of the adult population meeting criteria for obesity (National Heart Lung and Blood Institute, 1998). Obesity is associated with many adverse health consequences that are among the leading causes of death in the US (National Task Force on the Prevention and Treatment of Obesity, 2000a). Obese individuals with BED exhibit levels of eating disorder psychopathology and higher rates of psychiatric comorbidity than obese individuals without BED. In addition, binge eating impedes weight-loss efforts (Brody, Walsh, & Devlin, 1994; Eldredge & Agras, 1996; McGuire, Wing, Klem, Lang, & Hill, 1999; Orzano & Scott, 2004; Wilfley, Schwartz, Spurrell, & Fairburn, 2000; Wilson, Nonas, & Rosenblum, 1993; Yanovski et al., 1992). A better understanding is needed of the mechanisms and traits behind choice behavior such as binge eating and the behaviors leading to obesity in order to both develop and refine treatments for both disorders.

The concept of discounting offers a theoretical approach relevant to issues of impulsivity and self-control, such as that seen in individuals who binge eat (e.g., Bickel & Marsch, 2001; Logue, 1988). The use of a discounting procedure in the current study could help differentiate these groups in terms of impulsive behavior, self-control, and the value of rewards such as food. It is difficult for most individuals to focus on long-term benefits over short-term benefits, but it may be even more difficult for obese individuals or individuals with BED. Thus far, no study has examined the discounting of 'abused' rewards compared to other immediately reinforcing rewards in a clinical population such as individuals with eating disorders.

Merging the fields of basic science and clinical research has the potential to uncover novel methods of prevention and treatment strategies. For example, if discounting and its relation to impulsivity distinguish among the groups, then prevention

and treatment programs could be matched more specifically to individuals (Bickel & Marsch, 2001); identifying subgroups of more impulsive individuals who respond less well to treatment can lead to the development of more intensive treatments tailored to their specific strengths and weaknesses (Keel & Mitchell, 1997). The current study is conceived of as an initial step in determining whether the discounting paradigm should be explored further in these populations. Importantly, if these groups are found to differ in their degree of discounting, this finding also could be examined within the context of predictive validity for treatment outcomes, not just for binge eating or obesity interventions, but in other impulsive disorders, such as substance abuse, as well. Because delay and probability discounting have been found to have differential stability (of individual differences) and absolute stability (of group means), further predictive validity studies would be a logical next step (Ohmura, Takahashi, Kitamura, & Wehr, 2006). Understanding the central properties of eating behavior, such as the value that food holds to individuals, can aid in developing interventions for "abnormal" eating that might lead to obesity and eating disorders. This is the first study to use discounting in a clinical eating disorder and obese population, as well as the first discounting study to compare immediately consumable rewards in any clinical sample.

METHOD

Participants

The number of participants targeted for enrollment was chosen based on the effect size for discount rates in Kirby and Petry's (2003) examination of substance users versus controls (d = 0.90). Estimating a medium to large effect size with power of 0.80 to detect an effect using an ANOVA, the necessary total number of participants was calculated to be 90, with 30 participants in each group (Cohen, 1992). The BED group consisted of 30 obese [Body Mass Index (BMI) ≥ 30] female adults (ages 18 to 65)

meeting DSM-IV BED criteria[2] (American Psychiatric Association, 1994). The obese group consisted of 30 obese (BMI ≥ 30), non-binge-eating[3], female adults similar in age, ethnicity, and education to the BED group participants. The control group consisted of 30 normal-weight (BMI between 18 and 27), non-binge-eating female adults similar in age, race, and education to the BED group participants.

Interested participants were contacted by phone to determine initial eligibility criteria. Because participants needed to participate in tasks requiring sustained attention and a level of reading comprehension, exclusion criteria included the following: psychosis within the past 3 months, severe (suicidal) depression within the past 3 months, mental retardation, reading level below the 6th grade level, and past traumatic head injury. Further exclusion criteria included pregnancy, due to its impact on weight, and not being within driving distance of Washington University. To meet eating pathology criteria for the BED or obese group, participants had to meet DSM-IV BED criteria, or the non-binge-eating criteria, respectively. The control and obese groups were recruited to be as similar to the BED group as possible in terms of education, income, race, and age by continuously assessing these variables during recruitment. If a potential participant assessed over the phone was determined to engage in subclinical or other eating disorder behavior such as purging, she was offered treatment referrals.

Participants were recruited from the St. Louis area using Volunteers for Health, newspaper advertisements, phone logs from previous studies (when the participant had given permission for further contact), and flyers posted in the community (e.g., at community centers). Potential participants were instructed to call a designated number if

[2] BED criteria: Recurrent (average at least 2 times/week) episodes of binge eating (eating an amount of food in a discrete period of time that most people would consider unambiguously large, with a sense of loss of control) over the past six months. Absence of regular use of inappropriate compensatory behaviors (e.g., vomiting).

[3] Non-binge eating is defined as < 3 binges in the past six months and no more than one binge in any one month

they were interested in participating in an experiment on eating and women's health. All eligible participants were offered $30 in compensation for their participation and free group Behavioral Weight Loss (BWL) treatment at a later date.

Two hundred twenty women contacted the study with interest in participation, or were provided by Volunteers for Health as possibly eligible and interested participants. Of this number, 114 women were excluded due to not meeting eligibility criteria, not being interested in participating, or failing to attend the baseline assessment (see Figure 5). An additional 16 women were excluded after the in-person assessment. All women who did not meet study eligibility requirements were offered appropriate referrals, if desired. The remaining 90 women were considered eligible for participation and completed the study on the day of the in-person assessment. The phone screen procedure and full assessment battery was conducted initially on 15 interested female pilot participants who were studied, even if they engaged in subclinical eating behavior. They were offered the same amount of monetary and treatment compensation as the final study participants.

Figure 5.
Participant Recruitment

Reason for exclusion after phone screen	
	N
Subjective bulimic episodes	33
Unable to contact	18
Did not arrive at appointment	11
Compensatory behaviors	9
No longer interested	9

Included Participants	
	N
Binge eating disorder	30
Obese without BED	30
Normal-weight with no eating pathology	30
TOTAL INCLUDED	**90**

Ineligible BMI (b/t 27 & 30)	7
Over age 65	7
Unable to screen/Unclear eating episodes	5
No longer needed (on waitlist at end of study)	3
Subthreshold BED	4
Bulimia nervosa	2
Non-purging bulimia nervosa	2
Wanted medical exam	1
Too familiar with study aims	1
Cognitive deficits	1
No transportation	1
TOTAL EXCLUDED	**114**

Reason for Exclusion after In-person Assessment	
	N
Subjective bulimic episodes	10
Subthreshold BED	4
Compensatory behaviors	1
Night eating syndrome	1
TOTAL EXCLUDED	16
GRAND TOTAL EXCLUDED	**130**

Materials

Phone Screen Measures

During the phone screen, before the initial eligibility criteria were determined, demographic information (age, ethnicity, education, income, marital status, and contact information) was collected. Once initial eligibility requirements were met, an in-person assessment was scheduled.

Rewards Chosen

For discounting tasks, money typically has been used as the reward offered to participants. This paradigm has been extended to use rewards that serve as an "abused" substance, such as the drug of choice for substance abusers (e.g., Kirby & Petry, 2004). Other rewards have included future health (e.g., Chapman & Elstein, 1995; MacKeigan, Larson, Draugalis, Bootman, & Burns, 1993), food and alcohol (e.g., Estle, Green, Myerson, & Holt, 2007; Kirby & Guastello, 2001), and freedom (avoiding jail; Petry, 2003). The present study used the discounting tasks not only as a measure of at least one form of impulsivity, but also as a measure of how the clinical populations of binge eaters and obese viewed the reinforcing values of the rewards food and sedentary activity as compared to the widely recognized reward of money.

Further, some researchers (e.g., Estle, Green, Myerson, & Holt, 2007; Odum & Rainaud, 2003) have proposed recently that it is the *immediacy* and *consumability* of rewards such as illicit drugs that is the reason they are discounted more steeply than money, and not necessarily the reward's abuse potential itself. For example, unlike drugs, food, or sedentary activity that has to be immediately 'consumed' or used, money can be saved over time, which complicates the effects of delay. Thus, the control reward of massage time was conceived as a reward that serves as an immediate reward, like food and sedentary activity, but one that is not 'abused.' In other words, one aim of this study was to discern whether it is the *immediacy/consumability* of the reward

that is the important variable, or whether it is the *reward* itself that is the important variable.

Delay and Probability Discounting Tasks

Most studies that have used discounting tasks have used hypothetical rewards due to the cost of providing real rewards, but some researchers have discussed the validity of this procedure (e.g., Bickel & Marsch, 2001; Critchfield & Kollins, 2001). However, research has shown that individuals discount real rewards similarly to hypothetical rewards (Baker, Johnson, & Bickel, 2003; Johnson & Bickel, 2002; Kirby, 1997; Kirby & Marakovic, 1996; Lagorio & Madden, 2005; Madden, Begotka, Raiff, & Kastern, 2003; Rodriguez & Logue, 1988).

To complete the discounting tasks, participants were brought individually to a small room containing a computer with the discounting program (written using Visual Basic 6.0, Microsoft 1998) and monitor. They were provided with specific verbal as well as written instructions (see Appendix B) informing them that the purpose of this phase of the study was to examine their preferences for hypothetical amounts of money, food, sedentary activity, and massage time. The type of task (delay versus probability discounting) was crossed with amount (100 units versus 40 units) and reward (money, food, sedentary activity, massage time), resulting in 16 conditions. Each participant was studied in all 16 of these conditions. Half of the participants were assigned randomly to receive the delay discounting tasks first, and half of the participants were assigned randomly to receive the probability discounting tasks first. Within the delay or probability tasks, the order of reward determined randomly. Within the reward, the order of amount was determined randomly.

For the delay discounting task, participants were instructed that two amounts of hypothetical reward (money, food, sedentary activity, or massage time) would appear on the computer screen, and that one amount could be received immediately, whereas the

other amount could be received after some specified period of time. For the probability discounting task, participants were instructed that one amount could be received "for sure," whereas the other amount could be received with some specified probability. They also were told that the amount of the immediate/certain rewards would change after each of their choices, but that the amount of the delayed/probabilistic reward would remain the same for a group of choices. Participants were told that there were no correct or incorrect choices, and that they were to indicate their choice by clicking on their preferred option. After six practice trials, the experimenter ensured the participant was confident in the task, after which the experiment began; however, the participant was informed that the experimenter was in the next room if she had problems. For each type of reward, two amounts were studied: 40 units and 100 units. For money, the units were dollars; for food, the units were the smallest logical amount given the participant's choice (see Appendix C); for sedentary activity and massage time, the units were minutes. For the delay and probability discounting tasks, the position of the immediate/certain amount on the screen was randomized (i.e., for any given delay/probability condition, the immediate/certain amount was equally likely to be presented to the left or right of the delayed/probabilistic amount, with this left or right presentation staying consistent through the given delay or probability condition, but varying between conditions).

For each delayed amount studied with the delay discounting task, the participant made six choices at each of five delays: 1 week, 1 month, 6 months, 1 year, and 3 years. For this adjusting-amount algorithm, within each group of six choices, the amount of the immediate reward was adjusted using a staircase procedure that converges rapidly on the amount of immediate reward equal in subjective value to the delayed reward (for a detailed description of this procedure, see Du, Green, & Myerson, 2002). The first choice was always one-half the amount of the delayed amount. For example, if

the delayed amount was $100 in six months, then the immediate amount was $50 now. For subsequent choices, the size of the adjustment was half of the previous adjustment. Thus, if the participant chose $100 in 6 months over $50 now, then the next choice was between $75 now and $100 in 6 months; alternatively, if the participant chose $50 now over $100 in 6 months, then the next choice was between $25 now and $100 in 6 months. This procedure was repeated until the participant made six choices. For each trial, the immediate amount was representative of the current best guess of the subjective value of the delayed reward. Thus, the immediate amount that would have been presented on the seventh trial (if it existed) was used as an estimate of the subjective value of the delayed reward (Holt, Green, & Myerson, 2003; Myerson, Green, Hanson, Holt, & Estle, 2003). In other words, the subjective value was the amount of the immediate reward approximately equal in value to the delayed reward.

For each probabilistic amount studied with the probability discounting task, the participant made six choices at each of five probabilities: 90%, 75%, 50%, 25%, and 10% chance. An analogous adjusting-amount procedure was used to estimate the subjective value of probabilistic rewards. Within each group of six choices, the amount of the certain reward was adjusted using a staircase procedure that converges rapidly on the amount of certain reward equal in subjective value to the probabilistic reward. The amount that would have been presented on a seventh trial was used as an estimate of the subjective value of the probabilistic reward; that is, the amount of certain reward approximately equal in value to the probabilistic amount.

Self-Report Measures

In accordance with the study's fourth aim, two different impulsivity measures -- the UPPS Impulsive Behavior Scale (UPPS; Whiteside & Lynam, 2001) and the Barratt Impulsiveness Scale-11 (BIS-11; Patton, Stanford, & Barratt, 1995) -- were administered in order to explore the convergent and discriminative validity between the discounting

tasks and self-report measures. The UPPS is a 45-item scale derived in a factor-analytic method from the Five Factor Model of personality and is a commonly used impulsivity measure. It has four subscales that are related to impulsive behaviors: urgency, sensation seeking, (lack of) premeditation, and (lack of) perseverance (Whiteside & Lynam, 2001). These subscales have been found to differentiate eating disorder diagnostic categories (Claes, Vandereycken, & Vertommen, 2005; Miller, Flory, Lynam, & Leukefeld, 2003) and have demonstrated construct and divergent validity (Whiteside, Lynam, Miller, & Reynolds, 2005).

The BIS-11 is a widely used, 30-item measure of impulsivity that assesses the degree to which statements related to impulsiveness are associated with the individual's behavior. A total score as well as the subscales nonplanning ("planning and thinking carefully"), attentional impulsiveness ("focusing on the task at hand"), and motor impulsiveness ("acting on the spur of the moment") are generated (Patton, Stanford, & Barratt, 1995). This questionnaire has been normalized with a variety of groups, including college students and drug abusers (Allen, Moeller, Rhoades, & Cherek, 1998; Patton, Stanford, & Barratt, 1995). Cronbach's alpha coefficients across several groups range from .79 to .83 (Patton, Stanford, & Barratt, 1995). The I-7 is another often-used personality measure of impulsivity, but high correlations between the BIS-11 and the I-7 (Luengo, Carrillo-De-La-Pena, & Otero, 1991), and the frequency with which BIS-11 has been used in eating disorder populations (e.g., Nasser, Gluck, & Geliebter, 2004), led to its selection in this study.

For the purposes of confirming eating disorder diagnoses, assessing likely covariates of the discounting tasks, and establishing preferred food and sedentary rewards, the following eating measures were administered: Eating Disorder Examination (EDE; Fairburn & Cooper, 1993), the Eating Disorder Examination-Questionnaire (EDE-Q; Black & Wilson, 1996; Fairburn & Beglin, 1994), the restraint scale of the Dutch

Eating Behavior Scale (DEBQ-R; van Strien, Frijters, Bergers, & Defares, 1986), a Visual Analogue Scale assessing hunger (VAS; Flint, Raben, Blundell, & Astrup, 2000), a Snack Preference Measure (SPM; see Appendix E), and a Leisure Activities Questionnaire (LAQ; see Appendix F). The EDE was administered on the day of testing to confirm a BED diagnosis, or lack thereof, and to assess the key features of eating disorders (e.g., number of binge eating days and episodes, number of purging episodes, importance of shape or weight); a brief diagnostic version was used in order to minimize participant burden. The EDE is a standardized, investigator-based interview with established reliability and validity (Fairburn & Cooper, 1993; Rizvi, Peterson, Crow, & Agras, 2000).

Eating disorder psychopathology was assessed by the EDE-Q, the self-report form of the EDE, which includes the subscales of Restraint, Eating Concern, Weight Concern, and Shape Concern (Black & Wilson, 1996; Fairburn & Beglin, 1994). It has demonstrated good concurrent validity and acceptable criterion validity (Elder et al., 2006; Mond, Hay, Rodgers, Owen, & Beumont, 2004).

The restraint scale of the DEBQ was administered to measure the cognitive aspects of dietary restraint (versus behavioral aspects) in order to assess whether dietary restraint was correlated with the discounting tasks. The DEBQ has been referred to as the most "pure" of the available restraint scales because of its single-factor structure, high reliability and validity, and distinction from measurement of disinhibition, hunger, or weight fluctuation (Gorman & Allison, 1995). A reliable and valid measure of behavioral dietary restriction has not been developed. Thus, it has been suggested to measure dietary restriction by asking participants a single question of whether they are on a weight-loss diet (Lowe, 1993; Stice, Fisher, & Lowe, 2004). Accordingly, one question was added to the DEBQ: "Have you been trying to eat less for at least three

months, for the purpose of losing weight?" This question was used similarly to assess whether dieting was correlated with the participants' degree of discounting.

A VAS assessing hunger was given to participants a few minutes before the discounting tasks, again, for the purpose of assessing whether hunger was correlated with the degree of discounting. This method, using anchoring points on a continuum to assess hunger, fullness, and desire for food (see Appendix D), has been shown to be a reliable and valid measure of appetite (Flint, Raben, Blundell, & Astrup, 2000; Mattes, Hollis, Hayes, & Stunkard, 2005; Williamson et al., 2006).

Finally, a SPM was administered in order to determine the participant's highly desired snack foods to be used as the rewards in the discounting tasks. The SPM was developed for this study and contains seven categories of snack foods (non-chocolate candy, candy bar, chips, cookies, popcorn, crackers/hard pretzels, nuts/seeds; see Appendix E) selected to represent foods most likely to be overeaten. Likewise, the LAQ was administered in order to provide the participant's highly desired sedentary activities to be used as the rewards in the discounting tasks. The 12-item LAQ, developed for this study (see Appendix F), is very similar to methods used in other studies of sedentary activity (e.g., Epstein & Roemmich, 2001; Epstein, Saelens, Myers, & Vito, 1997).

In addition to the SPM and LAQ, participants were asked to provide the monetary value for their chosen rewards in order to determine whether the subjective value placed on rewards affects their degree of discounting. For example, if a participant chose a candy bar as her favorite category of snack food and watching TV as her most preferred leisure activity, she was asked to assign a monetary value to the unit of food by the question, "What is the maximum amount you would pay for a (candy bar)?" Likewise, she was asked to assign a monetary value to the leisure activity by the question, "What is the maximum amount you would pay to (watch TV)?"

On the day of testing, before the discounting tasks were administered, participants completed the widely used Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988). Earlier studies have shown that negative moods make it more likely that one will forego impulse control in favor of immediate gratification that will improve one's mood (Tice, Bratslavsky, & Baumeister, 2001); thus, this possibility also was assessed in this sample. The 20-item PANAS has demonstrated high internal consistency, stability over two months, and convergent and discriminant validity (Watson, Clark, & Tellegen, 1988).

In accordance with the third hypothesis of assessing the effect of comorbidity on the degree of discounting, and to determine study eligibility, participants completed two measures of general psychopathology. The Brief Symptom Inventory (BSI; Derogatis & Spencer, 1982) provided a continuous measure of psychological distress in which to examine the hypothesis. The BSI has shown very good test-retest and internal consistency reliabilities, and good convergent and construct validity (Derogatis & Spencer, 1982). The PRIME-MD Patient Health Questionnaire (PHQ; Spitzer, Kroenke, & Williams, 1999) is a categorical measure that was used to determine final eligibility criterion. The PHQ has shown good diagnostic validity, similar to the original PRIME-MD, but can be administered in a shorter amount of time (Spitzer, Kroenke, & Williams, 1999).

A "filler" questionnaire, the brief Health Anxiety Inventory (Salkovskis, Rimes, Warwick, & Clark, 2002), was administered prior to the discounting tasks for the purpose of decreasing the likelihood that participants would deduce the purpose of the study, thus lessening possible demand characteristics. The HAI was not analyzed. See Table 3 for a lay-out of the measures administered.

Table 3.

Study Measures

Domain	Measures
Demographic Information	Age, education, income, race, marital status
Impulsivity	UPPS
	Barratt Impulsivity Scale-11 (BIS-11)
Eating	Diagnostic Eating Disorder Examination (EDE)
	Eating Disorder Examination Questionnaire (EDE-Q)
	Dutch Eating Behavior Questionnaire-Restraint (DEBQ-R)
	Visual Analogue Scale for hunger (VAS)
Rewards	Snack Preference Measure (SPM)
	Leisure Activity Questionnaire (LAQ)
	Monetary Value of Rewards
Mood	Positive and Negative Affect Scale (PANAS)
General psychopathology	Patient Health Questionnaire (PHQ)
	Brief Symptom Inventory (BSI)
Filler	Health Anxiety Inventory (HAI)
Discounting	Delay
	Probability
Body Composition	Height
	Weight

Procedure

Once a participant met initial eligibility criteria over the phone, a 2-hour block of time was scheduled for the experiment at the university. Upon arrival, written informed

consent was obtained from each participant after the study's volunteer nature and procedures were reviewed to ensure comprehension. Demographic information received previously was confirmed. Weight then was assessed by a balance-beam scale, with participants in light clothing and no shoes, and height was assessed using a stadiometer. BMI (kg/m^2) was calculated from height (in meters) and weight (in kilograms) data.

Participants were administered the diagnostic version of the EDE to confirm that they met criteria for either the BED group, obese non-BED group, or control group. If, at this point, it was determined that the participant was not eligible for the study, she received appropriate referrals. If the participant was eligible, she continued in completing the PANAS, DEBQ-R, and VAS for hunger.

Participants then completed the discounting tasks in a private room. The discounting tasks were administered on a computer monitor, with the type of reward (e.g., food, money) and type of discounting task (i.e., probability or delay) delivered in random order. For the delay discounting task, participants were instructed that two amounts of hypothetical rewards would appear on the screen, and that they must choose between an amount they would receive immediately (e.g., $20 now) and another amount that would be received after a specified amount of time (e.g., $40 in six months). The instructions for the probability discounting task stated that one amount would definitely be received (e.g., 100% probability of receiving $50), whereas another amount would be received with a specified probability (e.g., 70% probability of receiving $100).

After completing the discounting tasks, the participant completed the questionnaires, then debriefed on the study and asked to sign a payment form. Participants were provided $30 in compensation for their participation and free group Behavioral Weight Loss (BWL) treatment. The participant was provided with information

regarding the upcoming treatment. The entire experimental session lasted approximately 1½ -2½ hours.

The weekly manualized group treatment began at a designated time after the experimental sessions were completed, and was conducted by two advanced clinical psychology doctoral students supervised by a licensed clinical psychologist. Data were not collected from the participants at these sessions. BWL has been found to be an effective treatment for obesity (Foster, Wadden, Kendall, Stunkard, & Vogt, 1996; Stunkard, 2000) and for binge eating (at least in the short-term; Marcus, Wing, & Fairburn, 1995). The standardized published protocol was used for this treatment.

STATISTICAL ANALYSES

Data were double-entered and, unless otherwise noted, analyzed using SPSS version 13.0 or 14.0 for Windows. Statistical significance for all tests was set at $p < 0.05$.

Preliminary Analyses

Ninety participants completed the study. In the self-report measures that were analyzed (BIS-11, BSI, DEBQ-R, EDEQ, PANAS, PHQ, UPPS, VAS), a minority of participants randomly missed answering <1% of all possible questions. When dealing with missing data, it is suggested that the variable should be retained when missing data are not extensive (<10% of cases having missing data on a given variable); thus, it was decided to treat the missing data rather than delete these cases (Cohen & Cohen, 1983). Case mean substitution is a method that assigns the participant's mean score of the present items, to the missing score (Raymond, 1986). This technique is particularly appropriate for self-report measures where all items reflect a specific concept assumed to be closely correlated (Fox-Wasylyshyn & El-Masri, 2005). Further, whereas multiple imputation is considered the most accurate imputation method, individual mean

imputations has been found to perform almost as well as, or slightly better than, multiple imputation in a questionnaire dataset (Shrive, Stuart, Quan, & Ghali, 2006). In this dataset, the mean was calculated from a participant's overall score when a single construct was assessed (e.g., depression from the BIS-11) or from the particular subscale in which the missing variable was located (e.g., one of the four subscales of the UPPS).

Descriptive Analyses

Participants in the three different groups were compared on seven demographic variables (age, race, BMI, years of education, income range, marital status, and number of children). For the continuous dependent variables of age, BMI, years of education, and number of children, nonparametric Kruskal-Wallace tests were performed to test group differences (Shapiro-Wilk normality tests, age: $p < 0.05$; all others, $p < 0.01$).

Primary Analyses

First Aim: To compare degree of discounting of delayed and probabilistic food, money, sedentary activity, and massage time as the rewards among women who are: (1) obese binge-eaters diagnosed with BED, (2) obese non-binge-eaters, and (3) normal-weight, non-binge-eaters.

For both delay and probability discounting, the subjective value of each delayed or probabilistic reward for each participant, and the median of each of the groups, was plotted as a function of the delay until, or the odds against, receiving the reward. Equation 1 (for delay) and Equation 2 (for probability) then were fit to the data using nonlinear least-squares techniques for each reward type and amount to determine the parameters of the best-fitting discounting functions.

Because of potential individual and group differences in the exponent (s) parameter of the hyperboloid equation, the discounting parameter (k and h) does not

necessarily, by itself, provide an independent measure of individual discounting. Individual parameter estimates for discounting functions also tend to be significantly positively skewed and thus, parametric statistical tests cannot be performed. An alternative method of measuring discounting is to calculate the area under the empirical discounting curve (AUC) for each participant (Myerson, Green, & Warusawitharana, 2001). Area measures, normalized based on the maximum possible subjective values and the maximum delay or odds against studied, can range between 0.0 and 1.0, with smaller areas indicating steeper discounting (Myerson, Green, & Warusawitharana, 2001). Because the area is calculated from the empirical discounting function (i.e., the actual data points) rather than from a function fit to the data, the obtained area measure does not depend on any theoretical assumptions regarding the form of the discounting function. In addition to being theoretically neutral, the AUC measure typically avoids the statistical problems created by skewed distributions because AUC is approximately normally distributed, and thus parametric statistical tests can be used to compare discounting data.

AUC values were used as the basis for assessing differences in the degree of discounting among the groups, amounts, commodities, as well as their interactions. AUC scores were calculated for each participant and exhibited substantial skew. Because the skew reflected the nature of the processes being examined, its removal via transformation was not attempted (nor would it have been possible given the nature of the skew). Rather, the skew was treated as the primary outcome of interest. However, since no developed sampling theory exists for the comparison of skew in mixed designs such as this, randomization and bootstrapping techniques were used to test hypotheses. These techniques replace intractable or nonexistent theoretical sampling distributions with empirical sampling distributions. Computer software to perform these analyses was written using Visual Basic, Version 5.0 (Microsoft, 1997).

Randomization and bootstrapping tests are both methods of resampling in which repeated samples are drawn from the obtained data in order to construct a sampling distribution for a statistic of interest. Randomization techniques (also called permutation methods) randomly resample from the data *without* replacement to test null hypotheses, whereas bootstrap methods randomly resample from the data *with* replacement to establish confidence intervals around parameter estimates (Berger, 2006). Both randomization and bootstrapping techniques were used with the present data in order to establish confidence in interpretation of the results, with significant results deduced only if the same conclusion was supported by the outcome of both techniques.

In the randomization technique, between-group assignments are randomly shuffled, maintaining the same group sample sizes and, for each participant, the profile of repeated measures is randomly shuffled as well. The logic behind this approach is that under the null hypothesis, the particular group label is meaningless as is the particular label attached to any particular measurement in the repeated measures profile. Thus, a large collection of random shuffles of the data (2000 in this study) produces a sampling distribution for a statistic of interest under the null hypothesis. In the current application, the skew was calculated within each condition after a particular random shuffle of the data and then contrasts corresponding to particular hypotheses were applied to the data. Each contrast represented a linear combination of skew values, constructed to test main effects, interactions, or conceptually important comparisons. The same contrasts were applied to the data as originally collected. The location of the original data contrast in the empirical sampling distribution was then used to test the relevant hypotheses. If the original data contrast fell in the lower or upper 2.5% of the empirical sampling distribution, it constituted a rare event under the null hypothesis and thus the null was rejected. The principal advantage of the randomization technique with the current data is that no theoretical sampling distribution is available for

comparing skew values. An additional advantage is that no assumptions about the shape or nature of the sampling distribution need to be made (Berger, 2006).

In the bootstrapping method, confidence intervals are estimated for the statistic of interest by randomly sampling with replacement from the observed scores to produce a new sample of the same size as the original sample; the skew is then calculated for each condition from this new sample and the contrasts applied to the skew values. This process is repeated thousands of times in order to produce an empirical sampling distribution for each contrast. The upper and lower confidence limits can then be established (Berger, 2006) and used for hypothesis testing by determining if the null hypothesis value is unusual (e.g., in the lower or upper 2.5% of the sampling distribution). Bootstrap confidence intervals do not depend on normality and may avoid misleading inferences from being drawn (Carpenter & Bithell, 2000), but first they must be adjusted for bias that can exist if the central tendency of the distribution and the actual obtained value from the sample are different. A variety of bias corrections have been proposed (Carpenter & Bithell, 2000; DiCiccio & Efron, 1996; Martin, 1990); for the current analyses, the bias-corrected and accelerated confidence intervals were used because this method has been thoroughly tested and performed as well as or better than other methods (Carpenter & Bithell, 2000; DiCiccio & Efron, 1996).

For both randomization and bootstrapping, 2000 samples were randomly drawn for each of 33 hypotheses. The 33 single-degree-of-freedom hypotheses involved group comparisons (e.g., Obese will be more skewed than Controls in delayed condition); reward comparisons (e.g., Food will be more skewed than money in the probability condition); and interactions of groups and rewards (e.g., Food will be more skewed than money; BED will be more skewed than Controls & Obese). Verbal descriptions of the comparisons are presented in Table 11. The actual contrasts consisted of weights used in the linear combination of skew values, with the weights normalized to have a sum of

squares equal to 1.00. For example, Table 4 shows the contrast codes used to create the linear combination of skew values for testing the hypothesis that food will be more skewed than money in the delay condition. Table 5 shows the contrast codes used to test the more complex hypothesis that food will be more skewed than money in the delay condition but that the degree of skew will be even greater for BED participants than for Controls and Obese (see Appendix G for the entire set of contrasts used).

Table 4.

Contrast Codes Used to Test the Hypothesis that Food will be more Skewed than Money in the Delay Condition.

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.2887	0.2887	0	0	0	0	-0.2887	-0.2887	0	0	0	0	0	0	0	0
Control	0.2887	0.2887	0	0	0	0	-0.2887	-0.2887	0	0	0	0	0	0	0	0
Obese	0.2887	0.2887	0	0	0	0	-0.2887	-0.2887	0	0	0	0	0	0	0	0

Table 5.

Contrast Codes Used to Test the Hypothesis that Food will be more Skewed than Money in the Delay Condition, especially for BED Compared to Controls and Obese.

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.4082	0.4082	0	0	0	0	-0.4082	-0.4082	0	0	0	0	0	0	0	0
Control	-0.2041	-0.2041	0	0	0	0	0.2041	0.2041	0	0	0	0	0	0	0	0
Obese	-0.2041	-0.2041	0	0	0	0	0.2041	0.2041	0	0	0	0	0	0	0	0

In order to rule out an effect of participants' subjective value of the rewards themselves on the rate in which they discounted the rewards, participants were asked the maximum amount they would pay for their chosen snack food item, and their chosen sedentary activity. Rather than delete the one outlying answer ($500; 8.48 SDs from the mean), this answer was changed to the maximum value ($100) for the category in which it fell (chosen sedentary activity). Partial correlations (controlling for income level and global psychopathology) were then conducted between the subjective value of the rewards and the AUC values.

Second Aim: To determine whether severity of obesity and/or severity of binge eating were correlated with the participant's degree of delay and probability discounting.

In order to determine whether participants' severity of obesity (as judged by BMI on the day of testing) was correlated with the degree of delay and probability discounting, the degree of discounting (AUCs) of the small and large amounts were first averaged before conducting partial correlations between the BMI of the BED and Obese groups, and the degree of discounting (controlling for binge eating severity, dietary restraint, and overall psychopathology). Similarly, BED participants' severity of binge eating (as judged by the average weekly number of objective bulimic episodes over the past six months) was partially correlated (controlling for obesity, dietary restraint, and overall psychopathology) with averaged delay and averaged probability degree of discounting.

Third Aim: To determine whether comorbid general psychopathology was correlated with the participant's degree of delay and probability discounting.

The BSI, used to gauge participants' level of psychopathology, produces the following scales: Global Severity Index (GSI), anxiety, depression, psychoticism, hostility, and somatization. The scales' T scores were partially correlated (controlling for BMI and positive and negative mood) with the participants' averaged delay and

averaged probability degree of discounting. In addition, since the BSI does not measure alcohol use, the index score of "preliminary alcohol abuse diagnosis" from the PHQ also was partially correlated with participants' averaged delay and averaged probability degree of discounting.

Since mood, hunger, restraint over eating, and dieting all may influence one's food choices, participants completed the PANAS (mood at the moment), VAS (hunger at the moment), DEBQ-R (restraint over eating), and the extra dieting question added to the DEBQ-R, before completing the discounting tasks. Partial correlations were conducted to determine whether any of these measures were associated with the degree of discounting. Participants' averaged delay and averaged probability degree of discounting were partially correlated with both scales of the PANAS (positive and negative mood at the moment; controlling for hunger, depression T scores, and anxiety T scores), the summed hunger rating of the VAS (hunger at the moment; controlling for negative mood, dieting, and restraint), the mean of the DEBQ-R (restraint over eating; controlling for hunger and dieting), and the extra dieting question added to the DEBQ-R (current dieting status; controlling for hunger and restraint).

Fourth Aim: To explore convergent and discriminative validity of impulsivity assessments by comparing questionnaire measures of self-control and impulsivity to the behavioral discounting computerized measures.

In order to explore the convergent and discriminative validity of impulsivity assessments, the averaged delay and averaged probability degree of discounting were partially correlated with the UPPS measure (comprised of the subscales Lack of Premeditation, Urgency, Sensation Seeking, and Lack of Perseverance) and the BIS-11 (comprised of the subscales Attentional Impulsivity, Motor Impulsivity, and Nonplanning Impulsivity), controlling for negative mood, binge eating severity, BMI, and overall psychopathology. Higher scores on the impulsivity questionnaires indicate more

impulsivity, whereas lower scores on discounting (less area under the curve) indicate more impulsive decision-making.

Fifth Aim: To evaluate the magnitude effect, determine if the magnitude effect was observed with different types of non-monetary rewards, and within these participant groups.

Shapiro-Wilk normality tests indicated that of the 16 AUC variables in the full sample, only the probabilistic reward of sedentary activity in the small amount was normally distributed. Because of this, the nonparametric Wilcoxon Signed Rank tests were used to test the magnitude effect with both the full sample and within the three groups.

RESULTS

Descriptive Analyses

For the continuous dependent variables of age, BMI, years of education, and number of children, there were no statistically significant differences among the groups, with, of course, the exception of BMI ($p < 0.001$; see Table 6). Participants were, on average, 47.38 years old (SD = 10.77). The majority of women self-identified as White (77.8%; n = 70), with the remainder of women identifying as Black (18.9%; n = 17), Hispanic (2.2%; n = 2), and Asian (1.1%; n = 1). According to self-report, 72.2% (n = 65) of the participants had at least one child (M = 1.56, SD = 1.37) and were highly educated: 8.9% (n = 8) reported completing or attending some high school; 28.9% (n = 26) reported completing some college/technical school; 30% (n = 27) reported graduating college; 10% (n = 9) reported completing some graduate school; and 22.2% (n = 20) reported earning a graduate/professional degree (M = 15.56, SD = 2.05). Their annual income level was high: 33.3% under $40K (n = 30), 33.3% $40-80K (n = 30), and 32.2% $80 to over-100K (n = 29; 1 participant refused to answer). A majority of the sample was currently married: 22% had never married (n = 20), 42.2% were married (n

= 38), 18.9% were divorced (n = 17), 13.3% were divorced and remarried (n = 12), and 3.3% were widowed (n = 3).

Table 6.

Sample characteristics: Continuous Variables

	Mean ± SD			
Participant variable	Controls *n* = 30	Obese *n* = 30	BED *n* = 30	FULL SAMPLE *N* = 90
Age	43.83 (12.38)	48.83 (9.56)	49.47 (9.58)	47.38 (10.77)
BMI (kg/m^2)	23.28 (2.38)[a]	42.60 (7.80)[b]	42.03 (9.79)[b]	35.97 (11.59)
Years of Education	15.73 (2.15)	15.73 (1.98)	15.20 (2.02)	15.56 (2.05)
Number of Children	1.10 (1.24)	1.80 (1.47)	1.77 (1.31)	1.56 (1.37)

Note. Differing letters indicate significant differences, $p < 0.001$

Participants' BMIs ranged from 18.00 to 70.00 kg/m^2 (M = 35.97, SD = 11.59). Evidence-based guidelines state that overweight ranges from a BMI of 25 to 29.9, obesity is defined as a BMI > 30, severe obesity is defined as a BMI > 35, and morbid obesity is defined as a BMI > 40 (National Heart Lung and Blood Institute, 1998). Thus, the obese groups' average BMI of 42.32 (SD = 8.78) is classified as morbidly obese. Follow-up Mann-Whitney tests found that, per the study inclusion criteria, the BMI values of the Obese and BED groups did not significantly differ ($p > 0.05$), but the BMI values between the Control and BED group, and the Control and Obese group, were significantly different ($ps < 0.001$). For the three demographic categorical variables of race, income range, and marital status, Chi-square tests revealed no significant differences among the groups (see Table 7; all $ps > .05$).

Table 7.

Sample Characteristics: Categorical Variables

	Frequencies (Percentage of Full Sample)			
Participant variable	Controls *n* = 30	Obese *n* = 30	BED *n* = 30	FULL SAMPLE *N* = 90
Race				
White	24 (80%)	21 (70%)	25 (83.3%)	70 (77.8%)
Black	4 (13.3%)	9 (30%)	4 (13.3%)	17 (18.9%)
Hispanic	1 (3.3%)	0 (0.0%)	1 (3.3%)	2 (2.2%)
Asian	1 (3.3%)	0 (0.0%)	0 (0.0%)	1 (1.1%)
Income*				
<$40K	12 (40%)	7 (23.3%)	11 (36.7%)	30 (33.3%)
$40-80K	7 (23.3%)	14 (46.7%)	9 (30%)	30 (33.3%)
$80 to over 100K	10 (33.3%)	9 (30%)	10 (33.3%)	29 (32.2%)
Marital Status				
Never married	7 (23.3%)	6 (2.0%)	7 (23.3%)	20 (22.2%)
Married once	12 (40%)	16 (53.3%)	10 (33.3%)	38 (42.2%)
Divorced	3 (1.0%)	4 (13.3%)	10 (33.3%)	17 (18.9%)
Divorced, remarried	7 (23.3%)	2 (6.7%)	3 (1.0%)	12 (13.3%)
Widowed	1 (3.3%)	2 (6.7%)	0 (0.0%)	3 (3.3%)

* 1 control participant chose not to answer

Discounting Functions

Delay Discounting

Figures 6 and 7 show the median subjective value of each delayed reward. Figure 6 shows these values for the small amount, and Figure 7 shows these values for the large amount. Each figure is composed of four panels, each representing the results

for a different reward. The symbols represent the subjective value of the delayed rewards by group, plotted as a function of the delay until receipt of the reward. The parameter values from the delay discounting data are shown in Table 8, which demonstrates that the data are well-described by Equation 1; the mean R^2 for the delay discounting curves is 0.95, and all R^2 values are larger than 0.84.

Figure 6
Plots of median subjective values: Delayed small amount

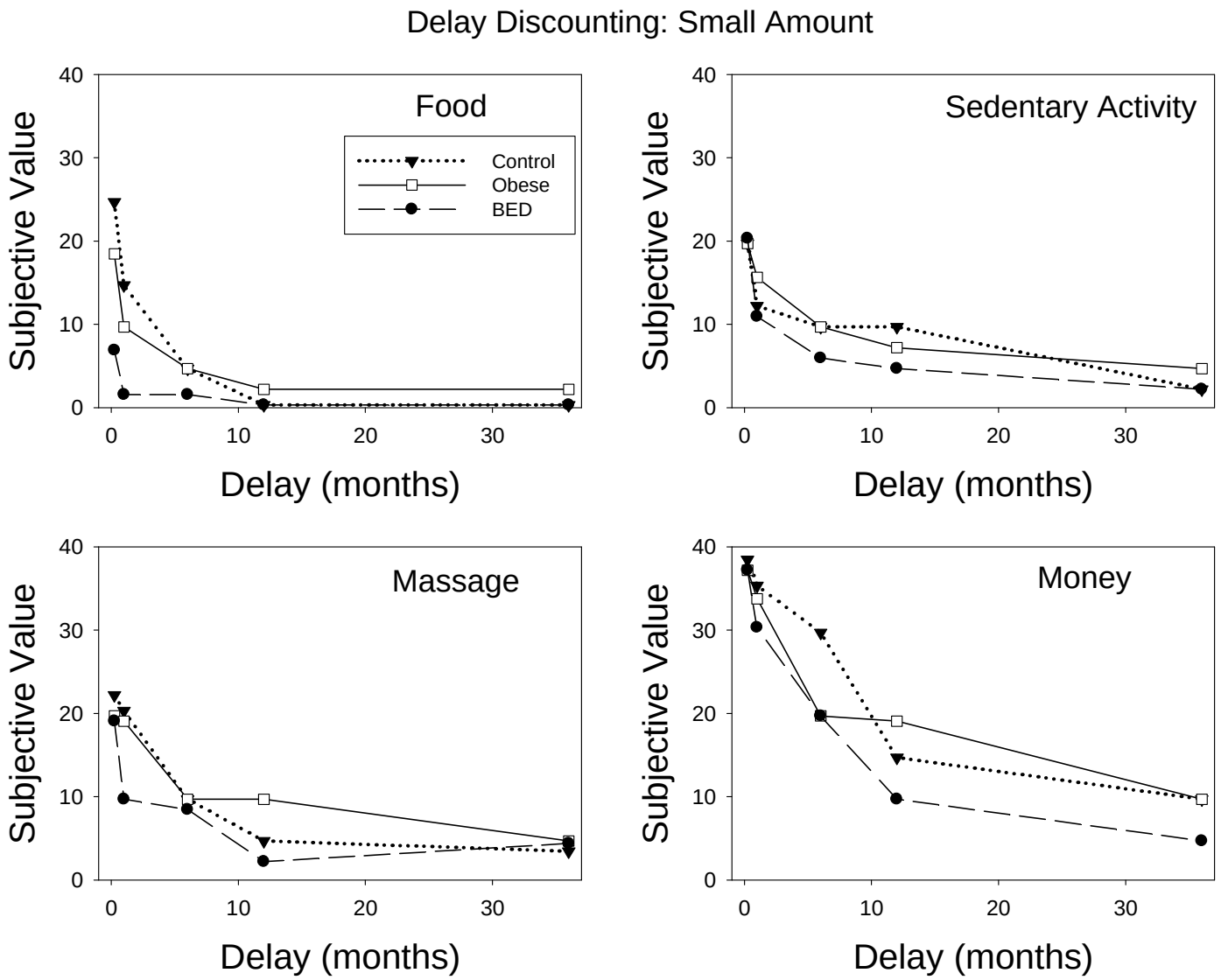


Figure 7
Plots of median subjective values: Delayed large amount

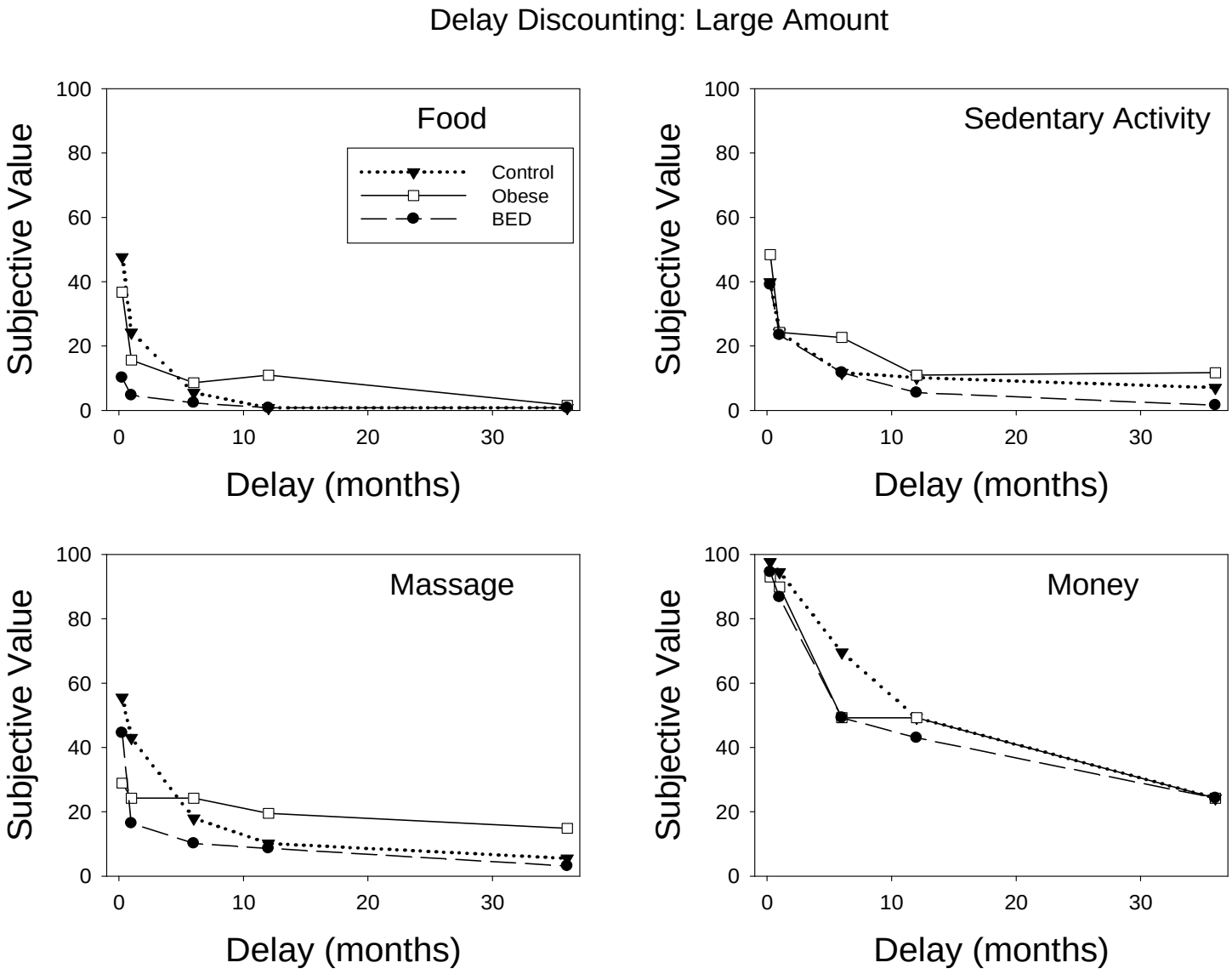


Table 8.

Delay Discounting Parameters

	BED			**Obese**			**Control**		
Small Amount	*k*	*s*	R^2	*k*	*s*	R^2	*k*	*s*	R^2
Food	28.00	0.86	0.94	14.80	0.50	0.99	2.96	0.80	0.98
Sedentary Activity	15.97	0.43	0.99	47.98	0.26	0.98	56.57	0.27	0.87
Massage	28.80	0.37	0.90	51.66	0.24	0.88	11.54	0.35	0.90
Money	0.31	0.83	0.98	0.53	0.44	0.98	0.07	1.22	0.95
Large Amount									
Food	274.42	0.54	0.99	32.36	0.47	0.94	5.95	0.79	0.99
Sedentary Activity	24.68	0.47	0.98	43.03	0.32	0.91	43.83	0.37	0.99
Massage	14.26	0.56	0.96	432790.24	0.11	0.84	9.47	0.43	0.96
Money	0.40	0.52	0.99	0.35	0.52	0.97	0.06	1.31	0.99

Probability Discounting

Figures 8 and 9 show the median subjective value of each probabilistic reward. Figure 8 shows these values for the small amount, and Figure 9 shows these values for the large amount. Each figure is composed of four panels, each representing the results for a different reward. The symbols represent the subjective value of the probabilistic reward by group, plotted as a function of the odds against receipt of the reward. The parameter values from the probability discounting data are shown in Table 9, which

demonstrates that the data are well-described by Equation 2; the mean R^2 for the probability discounting curves is 0.95, and all R^2 values are larger than 0.81.

Figure 8
Plots of median subjective values: Probabilistic small amount

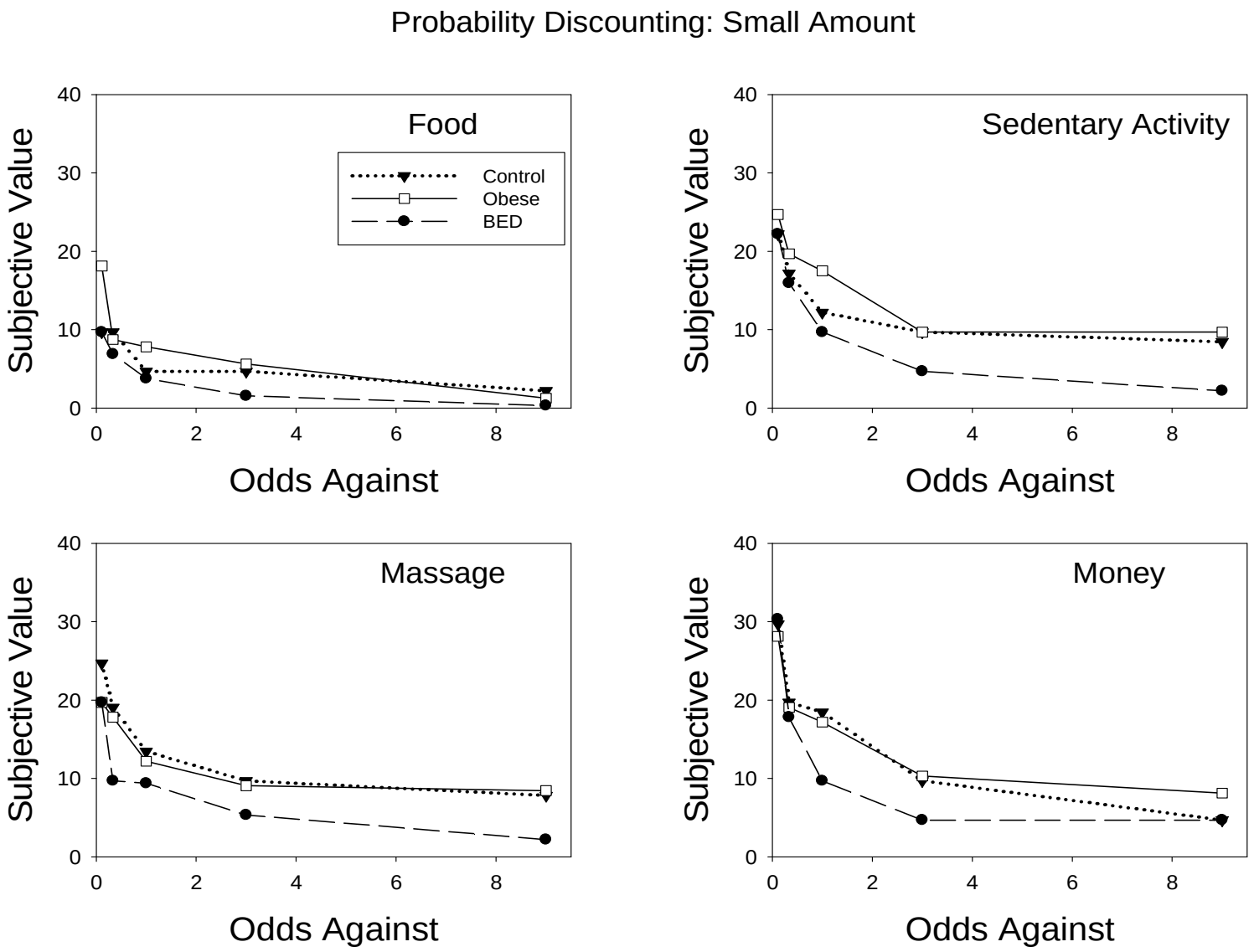


Figure 9
Plots of median subjective values: Probabilistic large amount

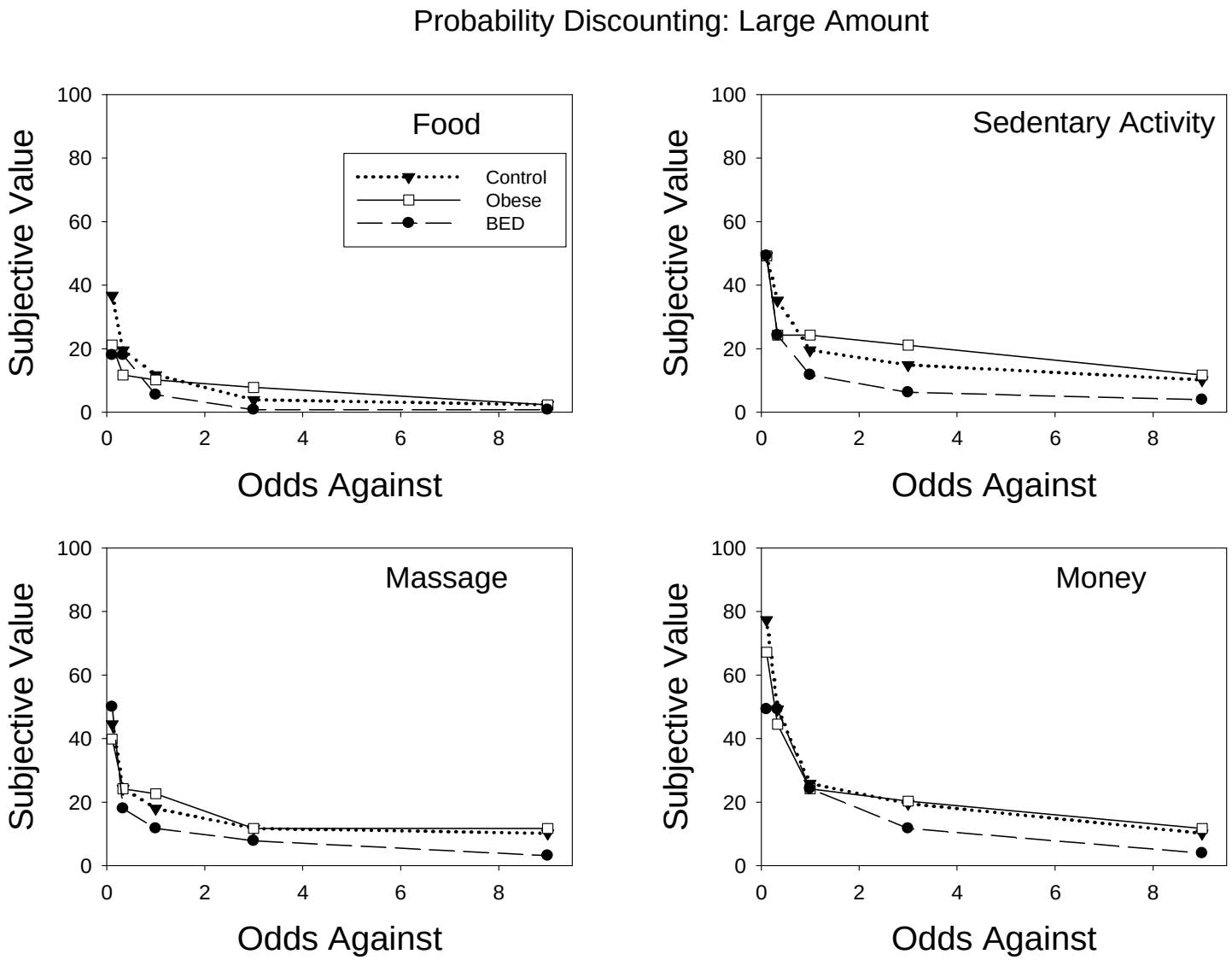


Table 9.

Probability Discounting Parameters

	BED			**Obese**			**Control**		
Small Amount	*h*	*s*	R^2	*h*	*s*	R^2	*h*	*s*	R^2
Food	131.05	0.50	0.97	46.76	0.46	0.93	975.66	0.28	0.86
Sedentary Activity	17.73	0.51	0.99	55.74	0.24	0.94	92.69	0.25	0.99
Massage	40.65	0.44	0.94	186.62	0.22	0.95	37.90	0.29	0.99
Money	5.25	0.73	0.98	22.60	0.30	0.97	10.30	0.40	0.95
Large Amount									
Food	199.01	0.51	0.81	618.59	0.37	0.94	33.98	0.64	0.99
Sedentary Activity	13.76	0.79	0.99	112.22	0.31	0.86	43.48	0.40	0.99
Massage	12.08	0.89	0.95	185.37	0.31	0.94	63.55	0.41	0.97
Money	22.38	0.45	0.88	13.00	0.48	0.98	5.74	0.63	0.98

Figure 10 presents box plots of the AUC values for the delayed rewards, averaged across the two amounts, for the control, obese and BED groups. Each panel represents the results for a different type of delayed reward. The bottom and top of each box represent the 25th and 75th percentiles, respectively, and the horizontal line within each box represents the group median (50th percentile). The vertical lines ("whiskers") extending from the boxes represent the minimum and maximum values that are not outliers, and outliers are represented by the points at the end of these lines. Outliers are defined as values above the 90th percentile, or below the 10th percentile. Positive

skewness is indicated by a box that extends higher above the median line than it does below, and a top whisker that is longer than the bottom whisker. The box plots show the consistency with which the BED group had lower AUC medians (i.e., greater delay discounting) and greater skew than the Obese and Control groups.

Figure 10
Box plots of the AUC values for delayed rewards

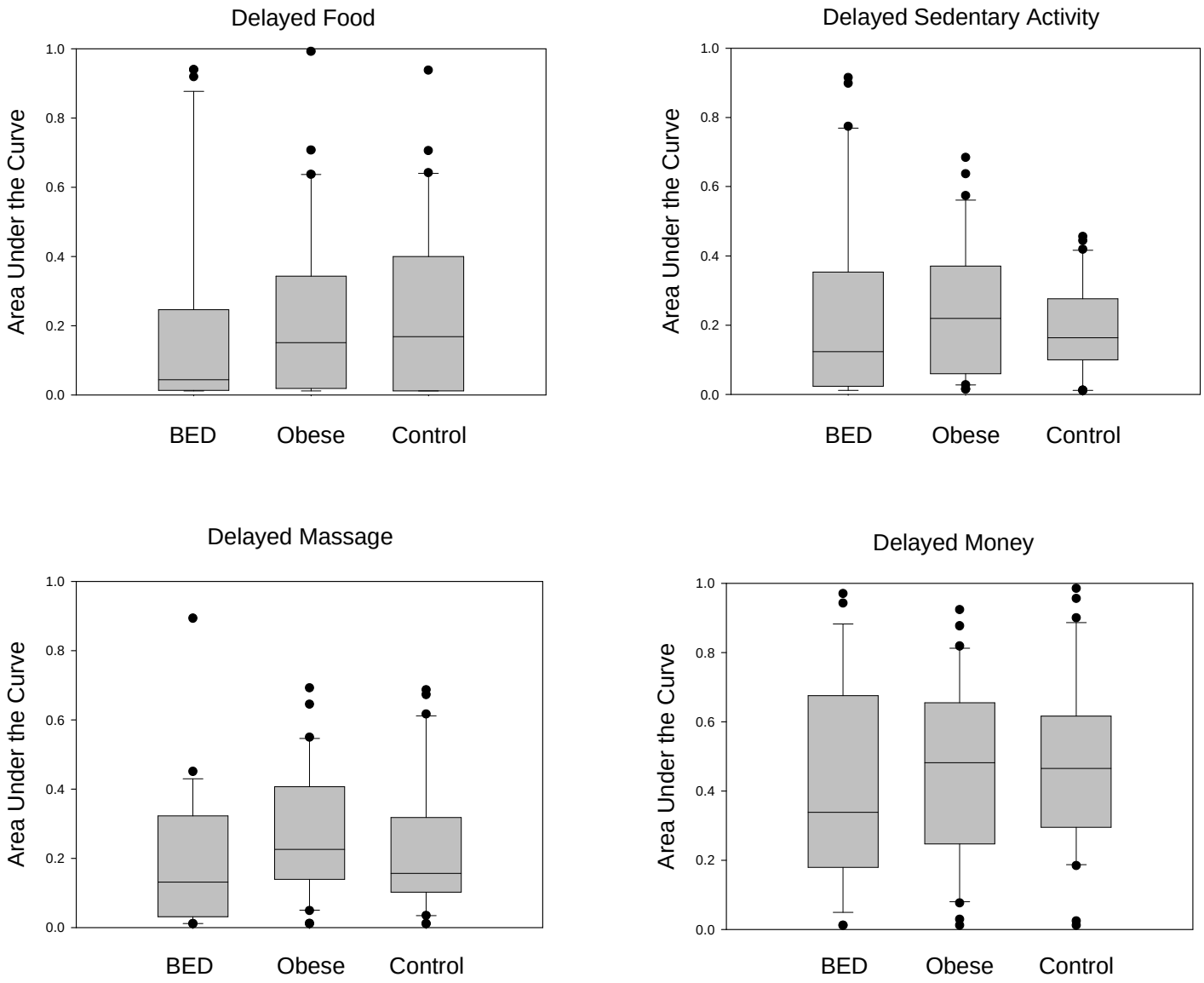
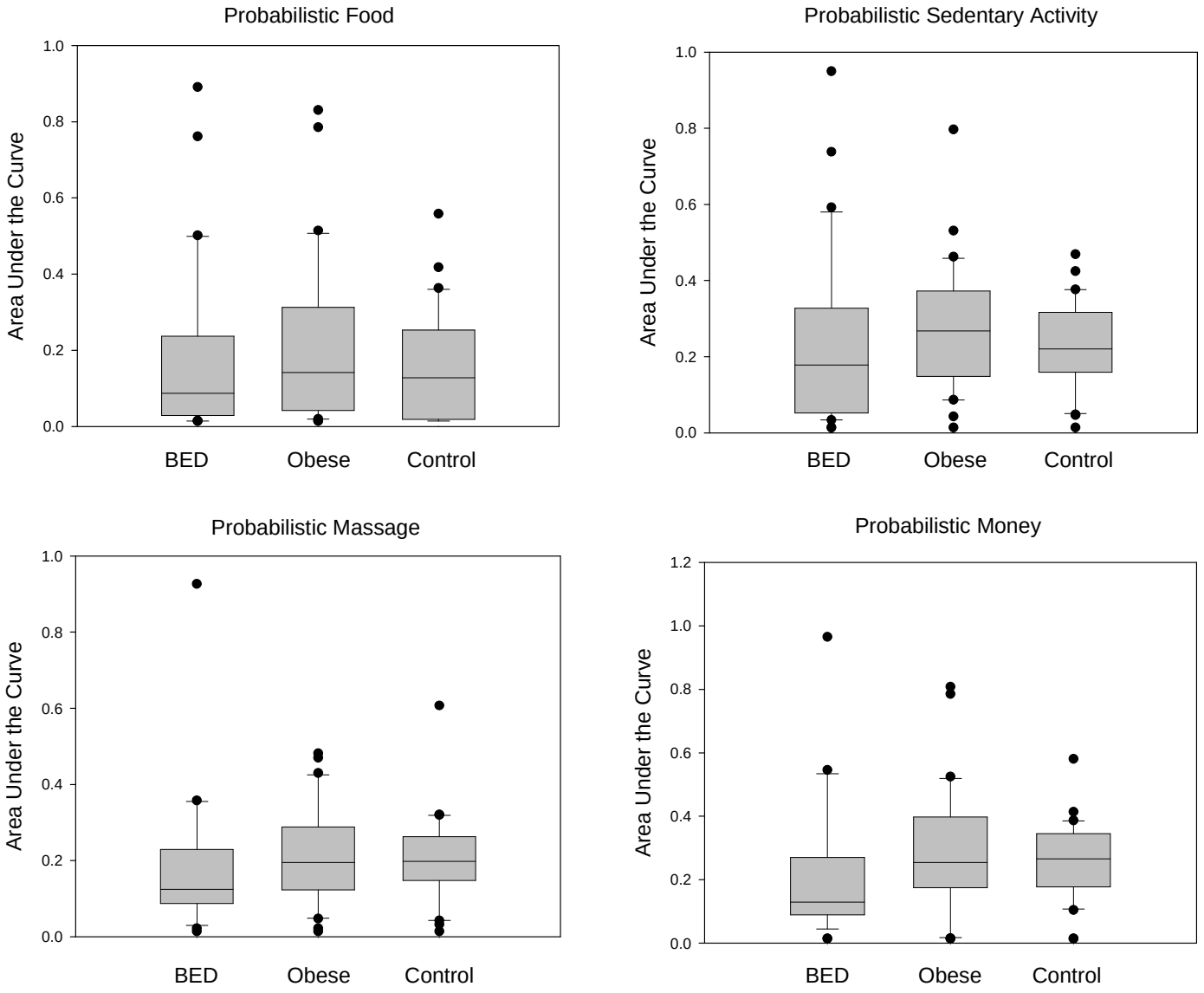


Figure 11 presents box plots of the AUC values for the probabilistic rewards, averaged across the two amounts, for the control, obese and BED groups. Each panel represents the results for a different type of probabilistic reward. The box plots show that, as was true for delayed rewards, the BED group consistently had lower AUC medians (i.e., greater probability discounting) and greater skew than the Obese and Control groups.

Figure 11
Box plots of the AUC values for probabilistic rewards



Primary Analyses

First Aim: To compare degree of discounting of delayed and probabilistic food, money, sedentary activity, and massage time as the rewards among women who are: (1) obese binge-eaters diagnosed with BED, (2) obese non-binge-eaters, and (3) normal-weight, non-binge-eaters.

When examining the relations between participants' subjective appraisal of the monetary values of the snack food and sedentary activity with the averaged delay and averaged probability degree of discounting, no significant correlations were found between the subjective monetary values of food and sedentary activity, and the AUC values regarding food and sedentary activity.

The AUC data were heavily and positively skewed across the full sample. Skew is most easily interpreted by its z-score, with a value ≥ 1.96 revealing a significant departure from normal, rendering data interpretation and parametric analyses problematic (Field, 2003). The average skew z-score for the averaged (between small and large amounts) delay and probability AUC values was 5.17, indicating significant and substantial departure from normal. Only the delayed reward of money was normally distributed, with a skew z-score of 0.686. Table 10 and Figure 12 show that skew varied considerably among groups, with the BED group appearing the most skewed as compared to the Obese and Control groups. Indeed, Table 10 reveals that the BED group is more positively skewed (indicating a left-stacked distribution, corresponding to smaller AUC values and more impulsive decision-making) in each of the eight discounting categories, averaged between small and large amounts. Figure 12 illustrates the number of participants by group who discounted delayed sedentary activity in various degrees, with the BED group showing the most participants who discounted sedentary activity steeply (smaller AUC values). Despite these visual depictions of the data, however, standard nonparametric tests to compare medians could not capture

these apparent group differences. Thus, it appeared that a more sensitive approach would be a nonparametric test to compare skewness. Because there is no theoretical sampling distribution for comparisons involving skew, the resampling methods of bootstrapping and randomization tests emerged as the best candidates for testing the hypotheses. Nonstandardized skew differences for the 33 one-way hypotheses are reported below in Table 11, followed by the mean skew corresponding to the significant main effects in Table 12. An example of the empirical sampling distribution that results from the bootstrapping approach is shown in Figure 13 for the hypothesis that BED participants will demonstrate more skew than Controls and Obese in the Delay Condition. The sampling distribution for the randomization test of the same hypothesis is shown in Figure 14. Both Figures 13 and 14 depict the frequency distribution of the data, containing 2000 individual contrast values generated for either the bootstrap or randomization analysis for that particular hypothesis. Each figure shows the distribution of the 2000 estimates, one from each sample.

Table 10.

Averaged (between Small and Large) AUC Skewness by Group

DELAYED REWARD	SKEW Z-SCORE
Food	
BED	5.36
Obese	3.18
Control	2.49
Sedentary Activity	
BED	3.42
Obese	1.84
Control	1.23

DELAYED REWARD	SKEW Z-SCORE
Massage	
BED	4.47
Obese	1.44
Control	2.78
Money	
BED	0.79
Obese	0.06
Control	0.55
PROBABILISTIC REWARD	
Food	
BED	4.14
Obese	3.72
Control	2.43
Sedentary Activity	
BED	3.69
Obese	2.17
Control	0.28
Massage	
BED	6.27
Obese	1.29
Control	2.83
Money	
BED	4.57
Obese	2.29

DELAYED REWARD	SKEW Z-SCORE
Control	0.44

Figure 12.

Skewness of delayed sedentary activity AUC values by group

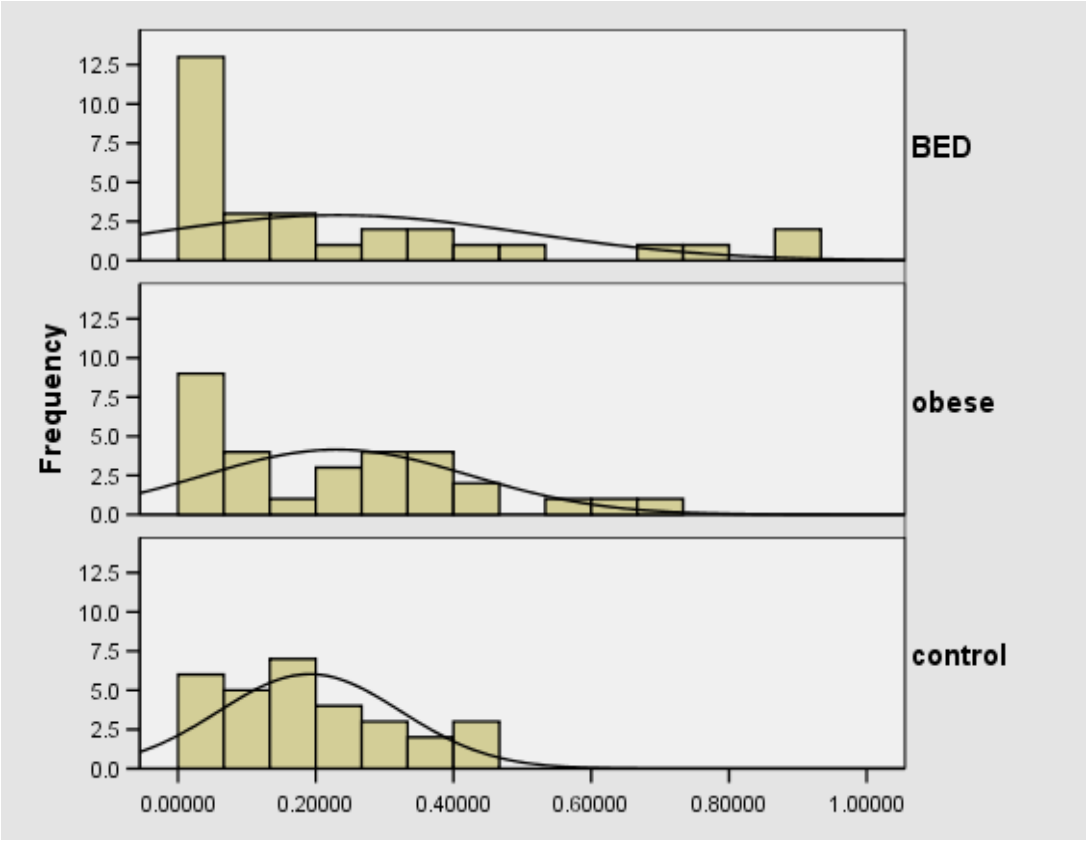


Figure 13.

Frequency distribution of bootstrap contrast values for the hypothesis: Delayed discounting of food will be more skewed than delayed discounting of money

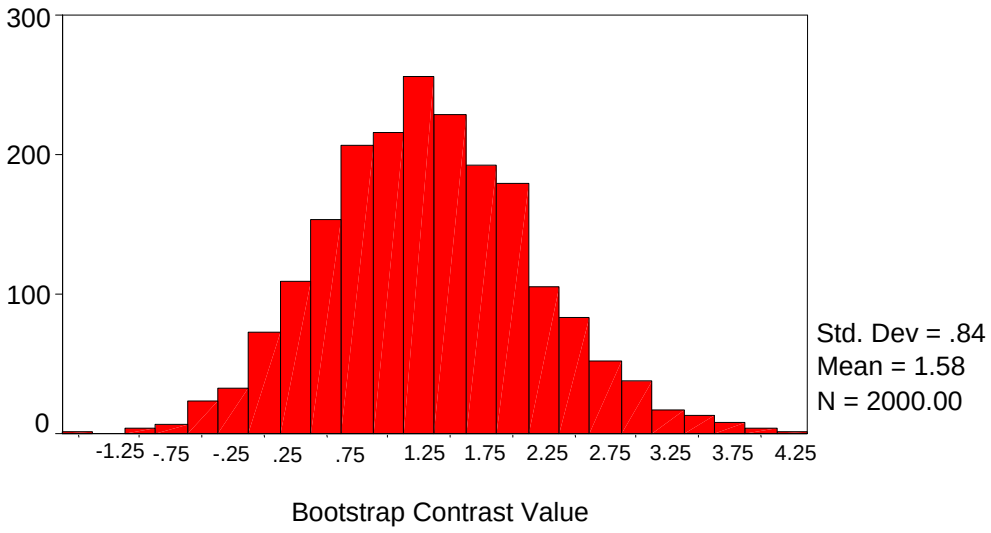


Figure 14.

Frequency distribution of randomization contrast values for the hypothesis: Delayed discounting of food will be more skewed than delayed discounting of money

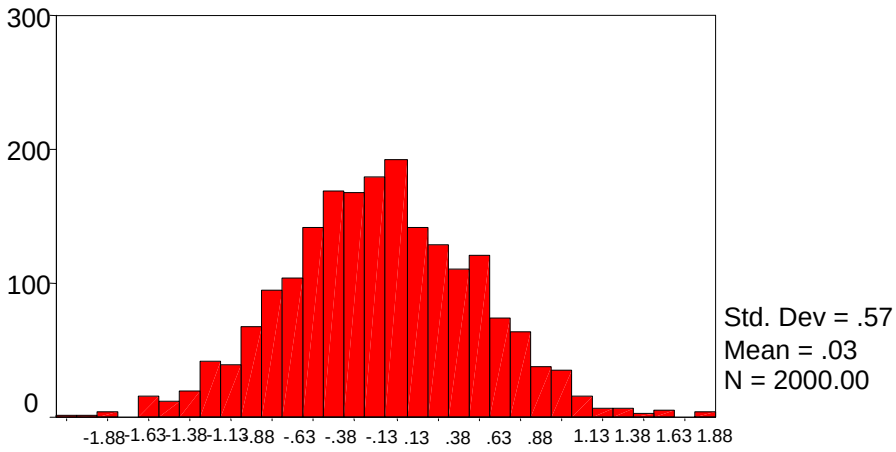


Table 11.

Nonstandardized Skew Differences for 33 Discounting Hypotheses

Hypothesis	Bias Corrected & Accelerated Bootstrap 95% Confidence Interval			Randomization Test Probability
	Lower Bound	Upper Bound	Significance Level	
Delay Discounting				
Food will be more skewed than money	1.57	3.62	p <0.005	<0.0001

Hypothesis	Bias Corrected & Accelerated Bootstrap 95% Confidence Interval		Randomization Test Probability	
	Lower Bound	Upper Bound	Significance Level	
Delay Discounting				
Food will be more skewed than massage & sedentary activity	-0.24	1.93	n.s.	0.0475
Massage & sedentary activity will be more skewed than money	1.43	3.09	p <0.005	<0.0001
BED will be more skewed than Controls & Obese	0.46	4.05	p <0.005	0.0025
Obese will be more skewed than Controls	-1.22	1.15	n.s.	0.8250
Food will be more skewed than money; BED will be more skewed than Controls & Obese	-0.10	2.33	p = 0.05	0.0255
Food will be more skewed than money; Obese will be more skewed than Controls	-0.52	1.19	n.s.	0.2545
Food will be more skewed than massage & sedentary activity; BED will be more skewed than Controls & Obese	-0.83	1.55	n.s.	0.2805
Food will be more skewed than massage & sedentary activity; Obese will be more skewed than Controls	-0.38	1.55	n.s.	0.1380

Hypothesis	Bias Corrected & Accelerated Bootstrap 95% Confidence Interval		Randomization Test Probability	
	Lower Bound	Upper Bound	Significance Level	
Delay Discounting				
Massage & sedentary activity will be more skewed than money; BED will be more skewed than Controls & Obese	-0.11	2.01	$p = 0.05$	0.0540
Massage & sedentary activity will be more skewed than money; Obese will be more skewed than Controls	-0.74	0.54	n.s.	0.7560
Probability Discounting				
Food will be more skewed than money	-0.34	1.97	n.s.	0.0115
Food will be more skewed than massage & sedentary activity	-0.37	2.08	n.s.	0.0100
Massage & sedentary activity will be more skewed than money	-0.86	1.56	n.s.	0.3755
BED will be more skewed than Controls & Obese	1.05	4.93	p <0.005	<0.0001
Obese will be more skewed than Controls	-0.71	1.92	n.s.	0.1180
Food will be more skewed than money; BED will be more skewed than Controls & Obese	-1.94	0.62	n.s.	0.1220

Hypothesis	Bias Corrected & Accelerated Bootstrap 95% Confidence Interval		Randomization Test Probability	
	Lower Bound	Upper Bound	Significance level	
Probability Discounting				
Food will be more skewed than money; Obese will be more skewed than Controls	-1.43	0.62	n.s.	0.3685
Food will be more skewed than massage & sedentary activity; BED will be more skewed than Controls & Obese	-2.06	0.59	n.s.	0.0795
Food will be more skewed than massage & sedentary activity; Obese will be more skewed than Controls	-1.19	1.21	n.s.	0.4295
Massage & sedentary activity will be more skewed than money; BED will be more skewed than Controls & Obese	-1.02	1.07	n.s.	0.9980
Massage & sedentary activity will be more skewed than money; Obese will be more skewed than Controls	-1.75	0.66	n.s.	0.2285
Interactions (Delay vs. Probability)				
Food will be more skewed than money	0.22	2.18	$p = 0.01$	0.0075
Food will be more skewed than massage & sedentary activity	-1.00	1.11	n.s.	0.7130

Hypothesis	Bias Corrected & Accelerated Bootstrap 95% Confidence Interval		Randomization Test Probability	
	Lower Bound	Upper Bound	Significance Level	
Interactions (Delay vs. Probability)				
Massage & sedentary activity will be more skewed than money	0.39	2.33	p <0.005	0.0015
BED will be more skewed than Controls & Obese	-3.24	0.41	n.s.	0.0540
Obese will be more skewed than Controls	-1.42	0.47	n.s.	0.1600
Food will be more skewed than money; BED will be more skewed than Controls & Obese	0.03	2.41	p <0.05	0.0110
Food will be more skewed than money; Obese will be more skewed than Controls	-0.35	1.35	n.s.	0.1360
Food will be more skewed than massage & sedentary activity; BED will be more skewed than Controls & Obese	-0.46	1.96	n.s.	0.0495
Food will be more skewed than massage & sedentary activity; Obese will be more skewed than Controls	-0.62	1.30	n.s.	0.2600

Hypothesis	Bias Corrected & Accelerated Bootstrap 95% Confidence Interval		Randomization Test Probability	
	Lower Bound	Upper Bound	Significance Level	
Interactions (Delay vs. Probability)				
Massage & sedentary activity will be more skewed than money; BED will be more skewed than Controls & Obese	-0.46	1.55	n.s.	0.1315
Massage & sedentary activity will be more skewed than money; Obese will be more skewed than Controls	-0.59	1.19	n.s.	0.2575

n.s. = not significant

Table 12.

Mean Skews Corresponding to Significant Main Effects

Hypothesis	**Reward**	**Mean Skew z-score**
Delay Discounting		
Food will be more skewed than money	Food	5.480
	Money	0.686
Massage & sedentary activity will be more skewed than money	Massage	4.442

Hypothesis	**Reward**	**Mean Skew z-score**
Delay Discounting		
	Sedentary Activity	5.461
	Money	0.686
	Group	
BED will be more skewed than Controls & Obese	BED	2.580
	Obese	1.710
	Controls	1.059
Probability Discounting		
BED will be more skewed than Controls & Obese	BED	2.946
	Obese	0.885
	Controls	0.689

For discounting of delayed rewards, all groups discounted food, sedentary activity, and massage time significantly more steeply than money ($p < 0.005$). For probability discounting, no discounting differences were found among rewards, although there was a trend towards food being discounted more steeply than money, sedentary activity, and massage time. With all rewards combined, BED participants differed significantly from obese and control participants in both delay ($p < 0.005$) and probability discounting ($p < 0.005$). For delay discounting, BED participants discounted food significantly more steeply than money to a greater degree than obese and control

participants discounted food more steeply than money ($p < 0.05$). Further, for delay discounting, BED participants discounted massage and sedentary activity significantly more steeply than money to a greater degree than obese and control participants discounted these rewards, at a trend level ($p = 0.05$). Obese participants did not differ from control participants in their discounting of delayed or probabilistic rewards.

Second Aim: To determine whether severity of obesity (as measured by BMI) and/or severity of binge eating (as measured by number of objectively large binges per week) are correlated with the participants' degree of delay and probability discounting.

Partial correlations (controlling for dietary restraint, binge severity, and overall psychopathology) revealed no significant correlations between levels of obesity (as measured by BMI) and the degree of discounting of the two obese groups (all *p*s > 0.05). However, BMI was negatively correlated with discounting of delayed food at a trend level ($r = -0.222$, $p = 0.053$). Similarly, BED participants' severity of binge eating (measured by average weekly number of objective bulimic episodes over the past six months) was not significantly partially correlated (controlling for dietary restraint, BMI, and overall psychopathology) with any degrees of discounting (all *p*s > 0.05). See Table 13 for more details. Exploratory analyses of the partial correlations between severity of binge eating and the impulsivity questionnaires (BIS-11, UPPS; controlling for BMI and overall psychopathology) revealed significant negative correlations of binge eating with the total BIS-11 score ($r = -0.356$, $p < 0.05$), the BIS-11 subscale Attentional Impulsivity ($r = -0.374$, $p < 0.05$), and the UPPS subscale Lack of Perseverance ($r = -.319$, $p < 0.05$).

Table 13.

*Partial Correlations of BMI, OBEs, and Averaged (between Small and Large) AUC Measures of Discounting**

	BMI [a]	OBE[b]
Delayed Reward		
Food	-0.222	0.015
Sedentary Activity	-0.115	0.115
Massage	0.085	-0.011
Money	-0.207	0.154
Probabilistic Reward		
Food	-0.073	-0.161
Sedentary Activity	-0.189	-0.252
Massage	0.025	-0.002
Money	-0.107	-0.155

* Smaller AUC values indicate steeper discounting, thus a negative correlation indicates steeper discounting is associated with higher values of the correlated variable

[a] Controlling for dietary restraint, overall psychopathology, OBEs

[b] Controlling for dietary restraint, overall psychopathology, BMI

Third Aim: To determine whether comorbid general psychopathology is correlated with participants' degree of delay and probability discounting.

Overall psychopathology (GSI) and the other BSI scales were negatively correlated with participants' degree of delay discounting; however, they were not as significantly correlated with the degree of probabilistic discounting. See Table 14 for a layout of the correlations.

Since mood, hunger, restraint over eating, and dieting all may influence one's food choices, partial correlations were conducted to determine if the PANAS (mood at the moment), VAS (hunger at the moment), DEBQ-R (restraint over eating), and the extra dieting question added to the DEBQ-R (current dieting status) were partially correlated with the averaged (between small and large) degree of discounting. The PANAS positive mood scale was negatively correlated with the averaged degree of discounting of delayed massage (r = -0.230, $p < 0.05$) when controlling for hunger, depression T scores, and anxiety T scores. The PANAS negative mood scale was positively correlated with the degree of discounting of sedentary activity (r = 0.215, $p < 0.05$), delayed food at a trend level (r = 0.211, p = 0.054), and probabilistic food (r = 0.289, $p < 0.01$). The VAS hunger scale (controlling for negative mood, dieting, and restraint), DEBQ-R (controlling for hunger and dieting), and the dieting question (controlling for hunger and restraint) were not significantly correlated with any of the degrees of discounting.

Table 14.

Partial Correlations[a] of BSI Psychopathology T scores and Averaged (between Small and Large) AUC Measures of Discounting[b]

	Global Severity Index	Anxiety	Depression	Psychoticism	Hostility	Somatization	Alcohol Abuse Dx[c]
Delayed Reward							
Food	**-0.351****	**-0.368****	**-0.331****	**-0.310****	**-0.259****	**-0.190***	0.031
Sedentary Activity	**-0.378****	**-0.353****	**-0.379****	**-0.380****	**-0.275****	**-0.197***	0.063
Massage	**-0.309****	**-0.206***	**-0.275****	**-0.315****	**-0.189***	-0.139	0.096

	Global Severity Index	Anxiety	Depression	Psychoticism	Hostility	Somatization	Alcohol Abuse Dx[c]
Delayed Reward							
Money	**-0.288****	**-0.228***	**-0.232***	**-0.220***	**-0.219***	**-0.210***	-0.021
Probabilistic Reward							
Food	**-0.241***	**-0.279****	-0.173	-0.177	**-0.250***	-0.181	0.062
Sedentary Activity	**-0.240***	**-0.283****	**-0.216***	-0.180	**-0.247***	-0.149	**0.211***
Massage	**-0.232***	-0.139	-0.154	-0.172	-0.128	**-0.211***	**0.276****
Money	-0.105	-0.053	-0.052	0.028	-0.127	-0.181	0.028

[a] Controlling for PANAS scales, BMI, and group

[b] Smaller AUC values indicate steeper discounting, thus a negative correlation indicates steeper discounting is associated with higher values of the correlated variable

[c] Item taken from the PHQ

* $p < 0.05$

** $p < 0.01$

Fourth Aim: To explore convergent and discriminative validity of impulsivity assessments by comparing questionnaire measures of self-control and impulsivity to the behavioral discounting computerized measures.

The results revealed significant positive correlations among three of the four UPPS subscales (Lack of Premeditation, Urgency, and Lack of Perseverance) and the BIS-11 total score and subscales (see Table 15).

Table 15.

Partial Correlations[a] *of UPPS and BIS-11 Scales*

	(Lack of) Premeditation	Urgency	Sensation Seeking	(Lack of) Perseverance
Total BIS	**0.325****	**0.203***	0.037	**0.241****
Attentional Impulsivity	0.080	0.019	0.090	**0.183***
Motor Impulsivity	**0.212***	0.100	0.084	0.015
Nonplanning Impulsivity	**0.408****	**0.309****	-0.072	**0.338****

[a] Controlling for PANAS negative scale, BMI, overall psychopathology, binge frequency, & group

* $p < 0.05$

** $p < 0.01$

However, the BIS-11 revealed very few significant correlations with the averaged degree of delay discounting and averaged degree of probability discounting, with only one negative correlation between the BIS-11 Total and Nonplanning Impulsivity with the degree of discounting of averaged delayed money ($p < 0.05$). None of the UPPS subscales was significantly correlated with the degree of discounting of the averaged delayed rewards (all *p*s > 0.05), and only two of the four subscales were significantly correlated with the averaged probabilistic rewards, but in a positive direction. The subscale Lack of Premeditation was significantly positively correlated with the averaged probabilistic reward of sedentary activity ($r = 0.216$, $p < 0.05$), and Urgency was significantly positively correlated with the averaged probabilistic rewards of food ($r = 0.275$, $p < 0.01$), sedentary activity ($r = 0.272$, $p < 0.01$), and money ($r = 0.211$, $p < 0.05$). See Table 16 for more details.

Table 16.

Partial Correlations[a] of Impulsivity Questionnaires and AUC Measures of Discounting[b]

	BIS-11				UPPS			
	Total	Attentional Impulsivity	Motor Impulsivity	Nonplanning Impulsivity	(Lack of) Premeditation	Urgency	Sensation Seeking	(Lack of) Perseverance
Delayed Reward								
Food	-0.010	-0.015	0.080	-0.080	0.060	0.165	-0.021	0.071
Sedentary Activity	0.123	0.054	0.177	0.048	0.102	0.045	-0.128	-0.019
Massage	-0.145	-0.153	-0.082	-0.101	0.121	-0.073	0.149	-0.123
Money	**-0.189***	0.021	-0.157	**-0.257***	-0.044	0.111	-0.047	0.035
Probabilistic Reward								
Food	0.053	-0.049	0.143	0.016	**0.178***	**0.275****	-0.020	0.174
Sedentary Activity	0.126	0.004	0.126	0.138	**0.216***	**0.272****	-0.156	0.083
Massage	-0.008	-0.100	0.112	-0.039	0.057	0.012	0.048	-0.070
Money	0.129	0.121	0.169	0.016	0.175	**0.211***	0.013	0.143

[a] Controlling for PANAS negative scale, BMI, overall psychopathology, binge frequency, & group

[b] Smaller AUC values indicate steeper discounting, thus a negative correlation indicates steeper discounting is associated with higher values of the correlated variable

* $p < 0.05$

** $p < 0.01$

Fifth Aim: To evaluate the magnitude effect, determine if the magnitude effect is observed with different types of non-monetary rewards, and within the participant groups.

Results indicated that the magnitude effect, namely that larger delayed amounts are discounted less steeply than smaller delayed amounts, was found with money. The $100 delayed reward was discounted significantly less steeply than the $40 delayed amount ($p < 0.01$). For the non-monetary delayed rewards of sedentary activity and massage, however, the larger amount was discounted more steeply than the smaller amount (sedentary activity, $p < 0.001$; massage, $p < 0.01$). There was no effect of amount on the discounting of delayed food ($p > 0.05$).

The magnitude effect with probabilistic rewards is opposite of that with delayed rewards. That is, larger probabilistic rewards are discounted more steeply than smaller probabilistic rewards. For all probabilistic rewards, the larger amount was discounted more steeply than the smaller amount (all *ps* < 0.001).

In examining the magnitude effect by group, overall patterns were similar to the results from the full sample. Differences among the groups were as follows: (1) the Control group was the only group for whom there was a significant magnitude effect for delayed money ($p < 0.05$); (2) the Obese group was the only group for whom there was *not* a significant magnitude effect for probabilistic food ($p > 0.05$); and (3) the Control group was the only group for whom there was *not* a significant magnitude effect for delayed massage ($p > 0.05$). Detailed results can be found in Table 17.

Table 17.

Magnitude Effects of Full Sample and by Group: Wilcoxon Signed Rank Test z-scores

Full Sample			
Delayed Reward	**Magnitude effect**: Large amount discounted less steeply than small amount	Small amount discounted less steeply than large amount	No effect of amount
Food			-0.404

Full Sample									
Delayed Reward	**Magnitude effect**: Large amount discounted less steeply than small amount			Small amount discounted less steeply than large amount			No effect of amount		
Sedentary Activity				**-4.514*** **					
Massage				**-3.294** **					
Money	**-2.892** **								
Probabilistic Reward	Large amount discounted less steeply than small amount			**Magnitude effect**: Small amount discounted less steeply than large amount					
Food				**-3.563*** **					
Sedentary Activity				**-6.061*** **					
Massage				**-7.171*** **					
Money				**-6.085*** **					
By Group									
	Controls			**Obese**			**BED**		
	Magnitude effect			**Magnitude effect**			**Magnitude effect**		
Delayed Reward	Lg amt discounted less steeply than sm	Sm amt discounted less steeply than lg	No effect of amount	Lg amt discounted less steeply than sm	Sm amt discounted less steeply than lg	No effect of amount	Lg amt discounted less steeply than sm	Sm amt discounted less steeply than lg	No effect of amount
Food			-0.852			-1.477			-0.165

	Controls			**Obese**			**BED**		
	Magnitude Effect			**Magnitude Effect**			**Magnitude Effect**		
Delayed Reward	Lg amt discounted less steeply than sm	Sm amt discounted less steeply than lg	No effect of amount	Lg amt discounted less steeply than sm	Sm amt discounted less steeply than lg	No effect of amount	Lg amt discounted less steeply than sm	Sm amt discounted less steeply than lg	No effect of amount
Sedentary Activity		**-3.676*** **			**-2.022***			**-2.095***	
Massage			-1.753		**-2.130***			**-2.274***	
Money	**-2.065***					-1.157			-1.870
		Magnitude effect			**Magnitude effect**			**Magnitude effect**	
Probabilistic Reward	Lg amt discounted less steeply than sm amount	Sm amt discounted less steeply than lg amount	No effect of amount	Lg amt discounted less steeply than sm amount	Sm amt discounted less steeply than lg amount	No effect of amount	Lg amt discounted less steeply than sm amount	Sm amt discounted less steeply than lg amount	No effect of amount
Food		**-3.057** **				-0.569		**-2.619** **	
Sedentary Activity		**-4.271*** **			**-3.471** **			**-2.755** **	
Massage		**-4.271*** **			**-4.033*** **			**-4.203*** **	
Money		**-3.074** **			**-3.917*** **			**-3.296** **	

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Exploratory Analyses

As an extension of this study's first aim (group differences in discounting) and fourth aim (convergent, discriminant validity of impulsivity measures), between-group differences of responses on the impulsivity questionnaires BIS-11 and UPPS were assessed by conducting a MANCOVA with group as the between-subject variable. The total score of the BIS-11, three BIS-11 subscales (Attentional Impulsivity, Motor Impulsivity, and Nonplanning Impulsivity), and four subscales of the UPPS (Lack of Premeditation, Urgency, Sensation Seeking, and Lack of Perseverance) were entered along with the covariates of participant age, education, and overall psychopathology. A significant group effect was found, $F = 2.05$, $p = 0.017$ (Pillai's Trace), indicating that the groups differed significantly on the combined set of impulsivity subscales.

Only the between-groups effects for Urgency, $F_{(2, 82)} = 8.70$, $p < 0.0001$ was significant, with Lack of Perseverance at a trend level, $F_{(2, 82)} = 2.79$, $p = 0.068$. Planned contrasts revealed that the BED group reported significantly higher ($p < 0.05$) Urgency ($M = 3.01$ on a 4-point scale) than the Obese ($M = 2.45$) and Control groups ($M = 2.21$). Further, the BED group reported significantly higher ($p < 0.05$) Lack of Perseverance ($M = 2.13$ on a 4-point scale) than the Control group ($M = 1.77$).

Further analyses were conducted as an extension of the third aim, to determine whether comorbid general psychopathology was correlated with participants' degree of delay and probability discounting. Even though the analyses of the third aim controlled for group, exploratory correlational analyses *by* group revealed that the significant relationships seen in Table 12 were due mostly to the significant relationships between the degree of discounting and psychopathology within the BED group. That is, within the Control group no significant correlations were seen between psychopathology and the degree of discounting, while in the Obese group only two significant correlations, between depression and the averaged delayed reward of food ($r = -0.477$; $p < 0.01$), and

between psychoticism and the averaged delayed reward of food (r = -0.336, p < 0.05) were observed. In the BED group, however, many significant correlations emerged, as shown in Table 18.

Table 18.

BED Group Only: Partial Correlations[a] of BSI Psychopathology T scores and Averaged (between Small and Large) AUC Measures of Discounting[b]

	Global Severity Index	Anxiety	Depression	Psychoticism	Hostility	Somatization	Alcohol Abuse Dx[c]
Delayed Reward							
Food	**-0.424***	**-0.485****	-0.337	**-0.391***	-0.334	-0.254	-0.086
Sedentary Activity	**-0.489****	**-0.493****	**-0.496****	**-0.473***	**-0.366***	-0.312	-0.121
Massage	**-0.543****	-0.350	**-0.397***	**-0.539****	**-0.355***	**-0.381***	-0.219
Money	**-0.405***	-0.330	-0.329	-0.336	**-0.389***	-0.228	-0.387
Probabilistic Reward							
Food	-0.315	**-0.459***	-0.222	-0.263	-0.337	-0.147	-0.095
Sedentary Activity	-0.331	**-0.418***	**-0.378***	-0.331	-0.310	-0.211	-0.019
Massage	-0.206	-0.095	-0.124	-0.076	-0.069	-0.213	0.129
Money	-0.102	-0.090	-0.054	0.042	-0.123	-0.161	-0.281

[a] Controlling for PANAS scales, BMI, and binge eating severity

[b] Smaller AUC values indicate steeper discounting, thus a negative correlation indicates steeper discounting is associated with higher values of the correlated variable

[c] Item taken from the PHQ

* p < 0.05

** p < 0.01

Also as an extension of the third aim, eating disorder psychopathology (as measured by the EDE-Q) was partially correlated with the averaged delay and averaged probability degree of discounting. Similar to the results listed in Table 18, correlational analyses by group revealed that the significant relations between eating disorder psychopathology and the degree of discounting were carried by the BED and Obese groups, as the Control group showed no significant correlations. Partial correlational analyses for the full sample are presented in Table 19. The BED and Obese groups showed similar positive correlations, contrary to the expected negative correlations.

Table 19.

Partial Correlations[a] of EDEQ Scales and Averaged (between Small and Large) AUC Measures of Discounting[b]

	Global	Dietary Restraint	Eating Concern	Weight Concern	Shape Concern
Delay Discounting					
Food	0.025	-0.065	0.022	0.061	0.072
Sedentary Activity	0.110	-0.108	0.022	**0.206***	**0.239***
Massage	0.054	-0.009	0.130	0.044	0.032
Money	**0.257***	**0.206***	**0.320****	0.180	0.145
Probability Discounting					
Food	-0.083	-0.147	-0.001	-0.023	-0.068
Sedentary Activity	0.172	0.091	0.105	**0.227***	0.135
Massage	0.026	-0.052	**0.243***	-0.010	-0.038
Money	**0.246***	0.089	**0.410****	**0.198***	0.154

[a] Controlling for PANAS negative, BMI, binge eating severity, overall psychopathology, and group

[b] Smaller AUC values indicate steeper discounting, thus a negative correlation indicates steeper discounting is associated with higher values of the correlated variable

* $p < 0.05$

** $p < 0.01$

DISCUSSION

This study compared discounting of delayed and probabilistic food, money, sedentary activity, and massage time among obese women with BED, obese women without BED, and normal-weight women. The results demonstrated that women in the BED group discounted delayed and probabilistic rewards more steeply than women in the Obese and Control groups, with no differences seen between the latter two groups. Further, all three groups discounted delayed food to a greater extent than delayed money, and the BED group discounted delayed food significantly more steeply, relative to delayed money, as compared to the Obese and Control groups. General psychopathology, but not eating disordered psychopathology, was significantly correlated with the degree of delay and probability discounting. Obesity, binge eating, and questionnaire measures of impulsivity were not highly correlated with the degree of discounting. These results indicate that women with BED choose rewards impulsively, especially in regard to food, and are more likely to be risk averse, than obese or normal-weight women, and that obese and normal-weight women do not differ from each other in this discounting task thought to measure impulsive decision-making.

Group and Reward Differences in Discounting.

To examine possible differences in impulsive decision-making among obese women with BED, obese women without BED, and normal-weight women, differences in the degree of discounting of food, money, sedentary activity, and massage time were

compared across groups. Group differences were indeed found, indicating possible differences in choice behavior among these participants outside the research setting, and providing external validity for discounting in a clinical group outside of substance abusers. No previous study has examined the discounting of 'abused' rewards compared to other immediately reinforcing rewards in a clinical population such as individuals with eating disorders. Consistent with the hypotheses of the study, with all rewards combined, women with BED differed significantly from obese and normal-weight women in both delay and probability discounting, indicating that women with BED tend to make more impulsive decisions (delay) and are more risk averse (probability) than women in the Obese and Control groups. The finding that women with BED make more impulsive decisions overall as compared to women in the Obese and Control groups is consistent with previous research that has found that individuals with BED tend to be more impulsive on questionnaire measures than controls (e.g., Galanti, Gluck, & Geliebter, 2007; Nasser, Gluck, & Geliebter, 2004). This is the first study to find that individuals with BED make more impulsive decisions on a behavioral (non-questionnaire) task and suggests that, while it may be challenging to focus on long-term benefits over short-term benefits, this process may be even more difficult for individuals with BED. Thus, a logical next research step would involve comparing treatment options or differential treatment outcomes for those individuals with BED who score more impulsively on either questionnaire or behavioral measures.

Making more impulsive decisions *and* being more risk averse – as seen in these women with BED – may seem counterintuitive. However, harm avoidance (Cloninger, Svrakic, & Przybeck, 1993) – a personality trait similar to risk aversion – is higher in individuals with eating disorders as compared to controls (e.g., Fassino et al., 2002; Klump et al., 2000), in individuals with BED as compared to obese individuals without

BED (Grucza, Przybeck, & Cloninger, 2007), and has been shown to predict eating beyond satiation (van den Bree & Cloninger, 2006). Further, in individuals with an eating disorder, having a comorbid impulse-control disorder has been associated with higher harm avoidance (Fernandez-Aranda et al., 2008), consistent with this study's findings. The BED group also may have presented as more risk averse because as a group they were more anxious ($p < 0.001$) than the Obese and Control groups, a characteristic shown to effect more cautious, risk-averse choices (Lerner & Keltner, 2000, 2001; Loewenstein, Weber, Hsee, & Welch, 2001; Raghunathan & Pham, 1999). That a difference in the discounting of probabilistic rewards was found between the BED and the other groups is a departure, however, from an earlier study that found no difference in probabilistic discounting between individuals scoring high and low on impulsivity measures (Ostaszewski, 1997). These findings on delay and probability discounting also provide further evidence against a unitary impulsivity construct underlying delay and probability discounting, where a significant negative relationship (from steep discounting of delayed rewards and shallow discounting of probabilistic rewards) would be expected if such a construct existed (Myerson, Green, Hanson, Holt, & Estle, 2003). At the very least, risk-taking does not appear to go hand-in-hand with an inability to delay gratification, a conclusion supported by other research (Holt, Green, & Myerson, 2003).

The group differences indicating that women with BED respond in ways signifying risk aversiveness and impulsive decision-making align well with cogent evidence that negative mood precedes binge eating (Hilbert & Tuschen-Caffier, 2007; Spoor et al., 2007; Stein et al., 2007), stress increases the reinforcing value of food in binge eaters (Goldfield, Adamo, Rutherford, & Legg, 2008), and avoidance distraction and negative affect are associated with emotional eating (Spoor, Bekker, Van Strien, & Van Heck, 2007), particularly in highly impulsive individuals (Bekker, van de

Meerendonk, & Molerus, 2004). Thus, it is not unreasonable to consider that individuals who make more impulsive decisions and/or are risk averse might be more likely to choose *immediate* rewards such as food to help *avoid* negative emotions. These negative emotions are highly concordant with the BED diagnosis, where cluster analyses have revealed subgroups of high and low negative affect (Grilo, Masheb, & Wilson, 2001; Loeb, Wilson, Gilbert, & Labouvie, 2000; Stice et al., 2001), and as many as 50% of individuals with BED suffer from a depressive disorder (Smith, Marcus, Lewis, Fitzgibbon, & Schreiner, 1998; Telch & Stice, 1998; Wilfley et al., 2000). This evidence on negative emotions and risk aversiveness, in conjunction with recent research indicating significant relations among the neurological *sensitivity to reward* (Wang et al., 2001), BMI (Davis & Fox, 2008; Davis, Patte et al., 2007; Franken & Muris, 2005), and binge eating (Davis, Levitan, Carter et al., 2007; Davis, Levitan, Kaplan et al., 2007) may indicate a possible etiological pathway by which obese women with BED may be more prone to respond to food – and possibly other immediate rewards – in an impulsive manner (Mobini, Grant, Kass, & Yeomans, 2007). The interactions among impulsivity, negative affect, and sensitivity to reward in obese and binge-eating individuals deserve more attention in the literature than it has received previously (van den Bos & de Ridder, 2006) and offers a rich future research direction.

For delay discounting, BED participants differed significantly from obese and control participants in discounting food more steeply than money, possibly demonstrating that women with BED are more likely to find food more reinforcing than money as compared to the other women. This finding is consistent with research that obese individuals work harder for access to food than the non-obese (Epstein & Leddy, 2006; Saelens & Epstein, 1996), a finding supported by animal models (la Fleur et al., 2007); however, the non-bingeing obese participants in this study did not discount

delayed food more steeply than money as compared to the normal-weight women. In fact, the Obese group did not differ from the Control group in their discounting of any delayed or probabilistic rewards. Therefore, this study suggests that obese individuals with BED may find food more reinforcing than money as compared to the Obese and Control groups, but more research is needed to determine whether obese individuals, with or without BED, find food more reinforcing than other individuals.

BED participants also differed significantly from obese and control participants in discounting sedentary activity and massage time more steeply than money. Sedentary activity has been shown to predict obesity (Hu, Li, Colditz, Willett, & Manson, 2003; Tucker & Bagwell, 1991), but the actual reinforcing value of sedentary activity in obese versus normal-weight individuals has received scant attention, with the research thus far restricted to the pediatric population. Consistent with this study's results, the pediatric research has found sedentary activity to have a greater relative reinforcing value for obese children than physical activity, and increasing in reinforcement as the level of obesity rises (Epstein, Smith, Vara, & Rodefer, 1991). Children with overweight/obese parents also have been found to have a stronger preference for sedentary activities and to spend more time in sedentary pursuits than children with normal-weight parents (Wardle, Guthrie, Sanderson, Birch, & Plomin, 2001). In this study, massage time functioned as a control variable, in that it was an immediately reinforcing reward, but not one that was hypothesized to be "abused" by an obese population. Thus, there were no *a priori* predictions as to the degree to which individuals would discount this nonconsumable reward. The finding with massage as the reward was consistent with the discounting of the immediately reinforcing rewards of food and sedentary activity in that BED participants discounted massage time more steeply than the generalized

conditioned reinforcer of money as compared to the obese and normal-weight participants.

This study also examined discounting between different rewards. For delayed rewards, it was expected that, similar to previous studies (Estle, Green, Myerson, & Holt, 2007; Odum & Rainaud, 2003), participants would discount food significantly more steeply than money. This hypothesis was indeed supported. Participants in all three groups discounted both sedentary activity and massage time more steeply than money. That is, in all three groups, as time to receipt increased, a greater percentage of the value of food, sedentary activity, and massage time was lost than the percentage of the value of money. Previous research has been unclear as to whether all directly consumable rewards are discounted equivalently, albeit more steeply than money, or whether a directly consumable reward abused by an individual has a special status, beyond its enhanced present value (Odum, Baumann, & Rimington, 2006; Petry, 2001a). Since delayed money was discounted less steeply than the three other directly consumable rewards, it appears to be the *timing* of the reward that is the important variable, and not the *content* of the reward. These findings support earlier research that discounting differences reflect a general property of consumable rewards rather than "abused" rewards holding special value for their "abuser" (Odum & Rainaud, 2003). Delayed money may be discounted less steeply than immediately consumable rewards because money retains its value and is exchangeable for other goods, whereas immediately consumable rewards such as alcohol or food are most valuable at the moment of discounting (Catania, 1998; Odum, Baumann, & Rimington, 2006). However, it is to be recalled that the BED participants *did* significantly differ as hypothesized from obese and control participants in discounting food more steeply than money, suggesting that an "abused" reward does matter for its "abuser." For probability discounting, it has

been reported that type of reward has no differential effect on discounting in non-obese participants (Estle, Green, Myerson, & Holt, 2007); it was unclear, however, whether a differential effect of reward type would be found in an obese or eating disordered population. Consistent with Estle et al. (2007), the BED and Obese groups performed similarly to non-obese participants; no differences between discounting of probabilistic rewards were found.

Group differences on the questionnaire measures of impulsivity (UPPS, BIS-11) were evaluated to determine whether differences seen in the discounting task also would be apparent on self-report measures. Exploratory analyses revealed that the BED group endorsed significantly higher Urgency (from the UPPS) – defined as the tendency, specifically in the face of negative affect, to act quickly and without planning (Whiteside & Lynam, 2001) – than the Obese or Control groups. Urgency was not correlated significantly with measures of delay discounting, although it was correlated positively with the discounting of probabilistic food, sedentary activity, and money (i.e., more risk-taking = higher urgency), and other studies have found urgency to be predictive of (Anestis, Selby, & Joiner, 2007), or associated with (Claes, Vandereycken, & Vertommen, 2005; Fischer & Smith, 2008), binge eating behavior. The key component of the Urgency definition may be "in the face of negative affect." Negative affect, in combination with higher harm avoidance and the expectation that food can alleviate negative affect, may contribute to the higher urgency and consequent binge eating seen in individuals with BED (Fischer & Smith, 2008; Stein et al., 2007). However, no other group differences in the impulsivity questionnaires subscales were found, once again highlighting the various definitions and multidimensionality aspect of impulsivity.

Currently, BED is a provisional diagnosis in the Diagnostic and Statistical Manual of Mental Disorders (DSM), 4th edition (American Psychiatric Association, 1994) as a disorder in need of further study. Extensive research, in the past decade

especially, has supported BED as a clinically significant disorder distinct from obesity without BED (e.g., Grucza, Przybeck, & Cloninger, 2007; Pope et al., 2006; Wilfley, Wilson, & Agras, 2003) that warrants inclusion in the upcoming DSM-V as a separate diagnosis (Hudson, Hiripi, Pope, & Kessler, 2007; Wilfley, Bishop, Wilson, & Agras, 2007). This study adds to this already abundant literature by demonstrating that a community sample of women with BED was significantly more likely to make impulsive decisions about rewards in an experimental task than obese or normal-weight women. Other research suggests that BED status moderates weight loss among individuals in weight treatment programs (Blaine & Rodman, 2007; Pagoto et al., 2007), and cognitive behavior therapy augments the effects of group weight loss treatment (Devlin, Goldfein, Petkova, Liu, & Walsh, 2007). Thus, if as this study suggests, individuals with BED tend to make more impulsive decisions than obese individuals without BED, then more intense psychological treatment focused on cognitive processes or emotional regulation (e.g., cognitive behavior therapy or dialectical behavior therapy; Telch, Agras, & Linehan, 2001; Wilson, 1999) may be more effective for individuals with BED than, for example, weight loss treatment focused on modifying behaviors. Whether a more intensive treatment is necessary for impulsive individuals with BED would be a question well-suited to a stepped-care treatment study. For example, cognitive behavior therapy could be added to a basic behavioral treatment such as bibliotherapy for individuals not responding to treatment (Masheb & Grilo, 2007; Wilson, Vitousek, & Loeb, 2000).

It also would be worthwhile for future research to examine the predictive power of discounting, in terms of treatment outcome, for individuals with BED, as the predictive value of discounting in treatment has thus far only been examined in research with nicotine (e.g., Krishnan-Sarin et al., 2007; Yoon et al., 2007), and to see whether extreme rates of discounting are amenable with more intensive treatments. These

answers also would aid in the development and implementation of prevention and treatment programs for other impulse-control disorders, such as substance use disorders.

Relations among Obesity, Binge Eating, and Discounting

It was hypothesized that levels of obesity and binge eating would be significantly correlated with the degree to which delayed but not probabilistic rewards are discounted. Support for this hypothesis included addiction literature that has found significant correlations between number of cigarettes smoked (Ohmura, Takahashi, & Kitamura, 2005; Reynolds, 2004), and alcohol addiction severity (Mitchell, Fields, D'Esposito, & Boettiger, 2005), and rate of discounting of delayed but not probabilistic rewards. In addition, binge severity (Nasser, Gluck, & Geliebter, 2004) and test-meal intake (Galanti, Gluck, & Geliebter, 2007) have been found to be significantly correlated with impulsivity as measured by the BIS-11. In this study, however, obesity and binge eating were not correlated with the degree of discounting either delayed or probabilistic rewards, supporting only our hypotheses of no effect regarding probabilistic rewards.

Levels of obesity (as measured by BMI) were not significantly correlated with the discounting of delayed or probabilistic rewards, although obesity and the discounting of delayed food were correlated at a trend level, offering some support to the external validity of food in the discounting task. It does not appear that obesity in and of itself is associated with the discounting of rewards, not surprising since the Obese group in this study did not differ from the Control group on discounting delayed or probabilistic rewards.

Severity of binge eating (as measured by the average number of weekly binges during the past six months) was not significantly correlated with the discounting of delayed or probabilistic rewards. However, 70% of the BED group had an average of 2-

3 binges weekly, so it may be that there was not enough variability to detect an effect. Future research should examine the association between severity of binge eating and discounting tasks in a larger sample.

Relations between Discounting and Psychopathology

As predicted, the degree of discounting of the delayed rewards of food, sedentary activity, and massage time were significantly correlated with the BSI measures of overall psychopathology, anxiety, depression, psychoticism (in this non-psychotic sample, measuring social alienation; Derogatis & Melisaratos, 1983), somatization (except for massage time), and hostility. A preliminary alcohol abuse diagnosis was not correlated with degree of delay discounting. Considering the history of significant associations between substance abuse and degree of discounting (e.g., Reynolds, 2006b), this finding likely was due to insufficient power given that only 7% of this study's sample endorsed a preliminary diagnosis of alcohol abuse. Money, while not immediately reinforcing, also was significantly correlated with all aspects of psychopathology except alcohol abuse. These results indicate that more impulsive decision-making is associated with higher psychopathology.

The probabilistic rewards of food, sedentary activity, and massage time were significantly correlated with global psychopathology. Psychoticism was not associated with the discounting of any of the probabilistic rewards. All other categories of psychopathology (anxiety, depression, hostility, and somatization) were correlated with at least one of the probabilistic rewards, except for a preliminary alcohol abuse diagnosis, which was correlated with the probabilistic rewards of sedentary activity and massage time. These results indicate that greater psychopathology was associated with *less* risk-taking, except for alcohol abuse, in which greater psychopathology was associated with more risk-taking.

However, exploratory analyses revealed that the high number of significant correlations likely was due to the significant relations seen between the BED group's degree of discounting (particularly on delay discounting) and levels of psychopathology, as measured by the BSI. The Control group's levels of psychopathology were not correlated with any discounting measures whereas the Obesity group's levels of depression and psychoticism were significantly correlated with the delayed reward of food. The external validity of food in the discounting task is again supported by this finding that depression and psychoticism (again, akin to measuring social alienation in a non-psychotic population) were correlated with impulsive decision-making around food, as both of these traits have been linked previously to excessive food consumption (e.g., Lauder, Mummery, Jones, & Caperchione, 2006; Stein et al., 2007; Stunkard, Faith, & Allison, 2003). It appears from these analyses that general psychopathology is indeed related to impulsive decision-making, a conclusion that is not surprising given the role impulsivity plays as a criterion for a variety of clinical disorders, ranging from substance abuse to borderline personality disorder (Dawe & Loxton, 2004; Evenden, 1999). However, this appears to be an area ripe for further research, especially as it pertains to the possibility that discounting could discriminate between other clinical disorders, or show particularly strong relations with impulse-control disorders such as kleptomania.

Despite these strong associations between psychopathology and discounting, especially in the BED group, other exploratory analyses did not find correlations in the expected negative direction between the degree of delay discounting and eating disordered psychopathology. Rather, the results with the delayed rewards suggest a relation between more impulsive decision-making and *less* eating disordered psychopathology, with significant results from the probabilistic rewards suggesting a relationship between more risk-taking and more eating disordered psychopathology, both of which run contrary to previous literature regarding impulsivity and eating

disorders (e.g., Claes, Vandereycken, & Vertommen, 2005), as well as the results from the primary aim of this study. It would be worthwhile to administer discounting tasks to individuals with other eating disorders such as bulimia nervosa or anorexia nervosa to ascertain whether these results can be replicated.

Relations among Impulsivity Measures

The impulsivity questionnaires UPPS and BIS-11 were more significantly related to each other (8 of 16 correlations significant) than either one of the questionnaires were related to the discounting tasks. Indeed, the UPPS was not significantly related to the discounting of *any* of the delayed rewards, whereas the BIS-11 was not significantly related to the discounting of *any* of the probabilistic rewards. It does appear, however, that the Urgency scale of the UPPS (defined as the tendency, specifically in the face of negative affect, to act quickly and without planning) is associated with risk-taking since it was positively associated with the discounting of probabilistic food, sedentary activity, and money. This may be a particularly salient subscale for future studies on impulsivity and binge eating to focus on, since the BED group also endorsed higher Urgency in this study than did the Obese and Control group. This is the first study to examine the UPPS in relation to other impulsivity measures, and the results provide evidence of significant relations with another self-report measure, but not with a delay discounting task.

Earlier studies have been equivocal in whether self-report measures of impulsivity are correlated with behavioral measures of impulsivity, including discounting (Bjork, Hommer, Grant, & Danube, 2004; Heyman & Gibb, 2006; Kirby, Petry, & Bickel, 1999; Mitchell, Fields, D'Esposito, & Boettiger, 2005; Mobini, Grant, Kass, & Yeomans, 2007; Richards, Zhang, Mitchell, & de Wit, 1999; Swann, Bjork, Moeller, & Dougherty, 2002), or whether these relationships are weak at best (Crean, Richards, & de Wit, 2002; Dom, De Wilde, Hulstijn, Van Den Brink, & Sabbe, 2006; Reynolds, Ortengren, Richards, & de Wit, 2006). Further, self-report questionnaires of impulsivity appear to be

more intercorrelated (e.g., Lane, Cherek, Rhoades, Pietras, & Tcheremissine, 2003; Reynolds, Ortengren, Richards, & de Wit, 2006) than the intercorrelations of laboratory-task measures of impulsivity behavior such as discounting (e.g., de Wit, Enggasser, & Richards, 2002; Reynolds, Ortengren, Richards, & de Wit, 2006; Reynolds, Richards, & de Wit, 2006). This study provides further evidence that self-report measures and behavioral measures assess different forms of impulsivity.

Within behavioral measures of impulsivity, one study aimed to further define impulsivity by performing a principal component analysis for four commonly used behavioral measures (Reynolds, Ortengren, Richards, & de Wit, 2006). Reynolds and colleagues found that two components were formed, one component whose loadings were significant was described as "impulsive decision-making," and included the delay discounting task and the Balloon Analogue Risk Task (a computerized, behavioral measure of risk-taking; Lejuez et al., 2002), whereas the other component was described as "impulsive disinhibition." Additional support comes from a discounting study (Estle, Green, Myerson, & Holt, 2007) where a factor analysis revealed that delay and probability discounting loaded on separate factors: the discounting measures of all four probabilistic rewards (money, beer, soda, and candy) had loadings greater than .75 on one factor and less than .35 on the other factor, whereas the reverse was true for the measures of the delayed rewards (Green & Myerson, in press). Other studies have performed similar principal component analyses to assess self-report measures of impulsivity (e.g., Petry, 2001c), or to form a new measure of impulsivity (UPPS; Whiteside & Lynam, 2001), but a study is greatly needed that will perform these or other sophisticated analyses on the full gamut of impulsivity measures – behavioral and questionnaire – in order to better elucidate the components of impulsivity and relations among these components.

Magnitude Effect

The magnitude effect for delayed rewards, namely that larger delayed amounts of rewards are discounted less steeply than smaller delayed amounts, was evaluated within the full sample, and by group, with similar results. In the full sample, the magnitude effect was seen for the delayed reward of money, consistent with previous research (e.g., Baker, Johnson, & Bickel, 2003; Green, Myerson, & McFadden, 1997; Johnson & Bickel, 2002). However, inconsistent with previous research that has found the magnitude effect for other non-monetary delayed rewards (e.g., Estle, Green, Myerson, & Holt, 2007; Schoenfelder & Hantula, 2003), the magnitude effect was not demonstrated for delayed food, sedentary activity, or massage. Further, the significant effect of amount was in the opposite direction for delayed sedentary activity and massage. Given the general consensus of the effect of amount on the delay discounting of money, demonstrating a magnitude effect with delayed money is not surprising. The effect of amount on the discounting of delayed rewards of food, sedentary activity, and massage are inconsistent with previous research, although research has found the magnitude effect to be smaller with consumable rewards than with monetary rewards (Estle, Green, Myerson, & Holt, 2007). The research on the effect of amount on non-monetary delayed rewards is too scant and requires further replication before firm conclusions can be made.

Consistent with previous research that had found an opposite magnitude effect with probabilistic rewards (e.g., Du, Green, & Myerson, 2002; Myerson, Green, Hanson, Holt, & Estle, 2003), that is, smaller probabilistic rewards are discounted less steeply than larger probabilistic rewards, the small probabilistic rewards of food, sedentary activity, massage, and money were discounted less steeply than the large amount.

Strengths and Limitations

Strengths of the current study include the large and ethnically representative (St. Louis region's Caucasian population is 75%, compared to the 78% proportion in this sample), and wide age range (18-65) of participants recruited from the community. Although the sample was highly educated (Mean years = 15.5), income levels were more diverse; thus, the results can be generalized safely to most adult women. Other strengths include the novel application of the discounting task to obese women with BED.

Limitations include the use of obese participants who were recruited in part by offering group behavioral weight loss treatment. Only a minority of the obese participants attended the behavioral weight loss sessions, but this population of obese women may perform differently on discounting tasks than obese women in the community who are not interested in losing weight. Thus, our findings are more safely generalizable to obese, treatment-seeking women. Additionally, it would be helpful for future research to validate the utility of food and sedentary activity in the context of a discounting task, for example, by offering the rewards chosen at the end of the task. Nevertheless, this study provided some evidence of their external validity in the context of a discounting task by finding group differences in the primary aim in the hypothesized direction, and a small correlation between obesity and the discounting of food.

Summary and Future Directions

Despite the fact that the DSM-IV criteria for BED includes impulsive characteristics such as lack of control over eating, research examining the relations between impulsivity and BED has not been widely conducted. Research that has been conducted has suggested that individuals with BED are more impulsive than obese or normal-weight individuals without BED (Galanti, Gluck, & Geliebter, 2007). This is the first study, however, to demonstrate a difference in impulsive decision-making for

women with BED on a behavioral task (rather than questionnaire), and with rewards that might be considered “abused” in this population – food and sedentary activity. Further, both delay and probability discounting appear to be highly correlated with at least one self-report measure of general psychopathology (BSI), indicating a need to assess individuals with other psychiatric disorders, especially impulse-control disorders. Conversely, the weak correlations between discounting and eating-disordered psychopathology, obesity, and severity of binge eating portend a need for further study. This study also replicated earlier research on the multidimensionality of impulsivity, noting little correlation between discounting and the self-report measures of impulsivity, and only moderate correlations between the two self-report measures of impulsivity. Research into impulsivity and its manifestations clearly would benefit from further delineation of the construct. Finally, this study replicated earlier research on the effect of amount on delayed money and probabilistic rewards, but did not find an effect of amount on degree of discounting delayed food, and found an effect of amount on the discounting of sedentary activity and massage time inconsistent with previous literature for non-monetary rewards, thus requiring replication (Estle, Green, Myerson, & Holt, 2007; Schoenfelder & Hantula, 2003).

Group differences were obtained in the decisions involving smaller and larger amounts of the same reward, such as a small amount of food now and a larger amount of food later, but a decision between food or sedentary activity now and a more abstract reward in the future (e.g., good health, lower weight) is perhaps a more appropriate conceptualization of the choices individuals make in Western society (van den Bos & de Ridder, 2006). Thus, future studies should compare the immediately gratifying variables with more abstract delayed variables that may be more ecologically valid. Also, consistent with other research that has found women with BED to endorse more psychopathology than obese women without BED, this BED group endorsed more

psychopathology than the Obese or Control groups. Thus, if future studies continue to study discounting within an eating-disordered population, it will be important to include a psychiatric control group. Future studies also need to study other psychiatric disorders within a discounting task as well, given its strong relationship with a self-report measure of psychopathology.

Clinical implications from this study will depend on future research. The findings in this study that women in the BED group made more impulsive decisions than women in the Obese and Control groups provides a window into possible reasons whereby specialty treatments are more effective in treating BED than more basic behavioral weight loss therapies that target food intake and physical activity. Currently, cognitive behavior therapy is the most well-established treatment for BED (Wilson, 2005), with interpersonal psychotherapy performing similarly to cognitive behavior therapy (Wilfley et al., 2002), and dialectical behavior therapy (Kristeller, Quillian-Wolever, & Sheets, 2004) showing promise (Telch, Agras, & Linehan, 2001). Cognitive behavior therapy works to modify maladaptive thoughts, interpersonal psychotherapy targets maladaptive interpersonal functioning, and dialectical behavior therapy targets dysregulated emotions and behavior. In this study, examining how individuals with BED responded to choices regarding food and other rewards, one can imagine how more basic behavioral weight loss therapy that advocates fewer high-caloric choices would be difficult for this group, and may not be as helpful as specialty treatments that target the factors that work to maintain the binge eating. Further, the high negative affect cluster seen within BED may present extra challenges for treatment (Masheb & Grilo, 2008). Dialectical behavior therapy, or other novel therapies that target impulsive behavior, may be useful for the subgroup of BED individuals with negative affect or impulsivity, and future research may determine that targeting impulsive behavior could impact not just the eating disorder, but other areas such as employment and relationships.

In addition, future studies to determine whether discounting tasks predict treatment outcomes for individuals with BED or other psychiatric disorders would be helpful in furthering the use of experimental tasks within clinical psychology. Finally, in order to further deconstruct the applications of discounting, it would be ideal to determine the relations among discounting and various clinical populations, rewards, and emotional states. The intersection of experimental and clinical science is just one avenue that needs to be explored comprehensively in order to provide novel insight into, and treatment for, obesity and binge eating.

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APPENDICES

Appendix A. Glossary

Introduction

Delay discounting: decrease in the subjective value of a reward as the time until its receipt increases.

Probability discounting: decrease in the subjective value of a reward as the odds against its receipt increases (probability decreases).

Impulsivity (behavioral definition): choice of a smaller, more immediate reward over a larger, more delayed reward.

Self-control (behavioral definition): choice of a larger, more delayed reward over a smaller, more immediate reward.

Discounting

Magnitude effect: Larger amounts of delayed rewards are discounted less steeply than smaller delayed amounts.

Preference reversals: Individuals often choose the smaller, more immediate reward over a larger, delayed reward, but this preference reverses when delays to both rewards are increased equally.

Delay effect: Discount rates tend to be higher for short delays than for longer delays.

Sign effect: Amounts framed as a gain in a discounting task are discounted at a higher rate than are equal amounts framed as a loss.

Domain independence: Individuals produce reliable discount rates *within* a domain, but demonstrate low discounting rate correlations *between* domains, such as that between health and money.

Discount utility theory (from economic theory): The same delay discount rate should be applied to all outcomes if goods are indeed exchangeable.

Impulsivity and Binge Eating

Binge Eating: eating an unambiguously large amount of food accompanied by a sense of loss of control.

Binge Eating Disorder (BED): recurrent episodes of binge eating (average of at least twice a week for six months) in the absence of regular use of inappropriate compensatory behaviors (e.g., vomiting, laxative use).

Appendix B. Verbal Instructions to Participants for Discounting Tasks

Adapted from Myerson, Green, Hanson, Holt, & Estle, 2003

The delay discounting instructions were as follows: ‘‘You will be asked to make a group of choices between hypothetical monetary alternatives. These choices will be displayed on the screen. On some trials, one amount of money is to be paid right now, and this amount will vary from trial to trial. The other amount of money will remain fixed, but its payment will be delayed. The screen will show you how long the delay will be. For each choice, if you would prefer to have the amount that is shown on the left, you will use the mouse to click on the left box. If you would prefer to have the amount that is shown on the right, you will use the mouse to click on the right box. If at any time you change your mind about a choice, you can return to the start of that group of choices by pressing the reset button at the bottom of the screen. There are no correct or incorrect choices. We are interested in the option you would prefer.’’

The probability discounting instructions were as follows: ‘‘You will be asked to make a group of choices between hypothetical monetary alternatives. These choices will be displayed on the screen. On some trials, one amount of money is to be paid for sure, and this amount will vary from trial to trial. The other amount of money will remain fixed, but its payment will be probabilistic. The screen will show you what the probability will be. As before, for each choice, if you would prefer to have the amount that is shown on the left, you will use the mouse to click on the left box. If you would prefer to have the amount that is shown on the right, you will use the mouse to click on the right box. If at any time you change your mind about a choice, you can return to the start of that group of choices by pressing the reset button at the bottom of the screen. Remember, there are no correct or incorrect choices. We are interested in the option you would prefer.’’

Appendix C. Examples of Amounts of Food Reward

Each amount given is equivalent to one unit

Category

1. **Candy**: **non-chocolate:** 1 bag (vending machine sized)
2. **Candy bar**: 1 candy bar
3. **Chips**: 1 bag (vending machine sized)
4. **Cookies:** 1 package (vending machine sized)
5. **Popcorn**: 1 single-serving bag
6. **Crackers/hard pretzels**: 1 bag (vending machine sized)
7. **Nuts/seeds:** 1 bag (vending machine sized)

Appendix D. VAS Hunger Rating

1. How hungry do you feel?

I am not hungry at all						I am famished
0	1	2	3	4	5	6

2. How satisfied do you feel?

I am completely empty						I cannot eat another bite
0	1	2	3	4	5	6

3. How full do you feel?

Not at all full						Totally full
0	1	2	3	4	5	6

4. How much do you think you can eat?

Nothing at all						A lot
0	1	2	3	4	5	6

5. Would you like to eat something sweet?

No, not at all						Yes, very much
0	1	2	3	4	5	6

6. Would you like to eat something salty?

No, not at all						Yes, very much
0	1	2	3	4	5	6

7. Would you like to eat something savory/flavorful?

No, not at all						Yes, very much
0	1	2	3	4	5	6

8. Would you like to eat something fatty?

No, not at all						Yes, very much
0	1	2	3	4	5	6

Appendix E. Snack Preference Measure

Imagine that you are at a vending machine. Assuming this machine has your favorite brand or item in each category, which of the 7 categories listed below would you most prefer? Please indicate your most-preferred category by listing its name and number below.

Category

1. **Candy**: **non-chocolate** (e.g., Skittles™, jelly beans, Sweet Tarts™)

2. **Candy bar**: chocolate (e.g., Snickers™, M&M's™, Hershey's bar™, 3 Musketeers™)

3. **Chips** (e.g., potato, corn, tortilla, Cheetos™, Funyuns™)

4. **Cookies** (e.g., Oreos™, Chips Ahoy!™, Nutter Butter™)

5. **Popcorn** (e.g., butter, kettle korn)

6. **Crackers/hard pretzels** (e.g., Ritz™, Wheat Thins™, graham crackers)

7. **Nuts/seeds** (e.g., peanuts, cashews, sunflower seeds)

Of the 7 categories of snack items listed above, which would you most prefer:

_____

Appendix F. Leisure Activities Questionnaire

Which of the following leisure activities do you most prefer? Please choose only one, and write the number/category here:

_____

1. Watching TV/videos
2. Playing video/computer games
3. Reading (e.g., magazines, books, newspapers)
4. Driving
5. Surfing the Internet
6. Sleeping/napping
7. Playing solitary games (e.g., crossword puzzles, Sudoku, Solitaire)
8. Playing board games/card games
9. Going to movie/play/show
10. Talking on the phone
11. Writing/journaling
12. Other (List _____)

Appendix G. Contrasts codes for 33 discounting hypotheses

1. Food will be more skewed than money (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.288675	0.288675	0	0	0	0	-0.288675	-0.288675	0	0	0	0	0	0	0	0
Control	0.288675	0.288675	0	0	0	0	-0.288675	-0.288675	0	0	0	0	0	0	0	0
Obese	0.288675	0.288675	0	0	0	0	-0.288675	-0.288675	0	0	0	0	0	0	0	0

2. Food will be more skewed than money (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0.288675	0.288675	0	0	0	0	-0.288675	-0.288675
Control	0	0	0	0	0	0	0	0	0.288675	0.288675	0	0	0	0	-0.288675	-0.288675
Obese	0	0	0	0	0	0	0	0	0.288675	0.288675	0	0	0	0	-0.288675	-0.288675

3. Food will be more skewed than money (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.204124	0.204124	0	0	0	0	-0.204124	-0.204124	-0.204124	-0.204124	0	0	0	0	0.204124	0.204124
Control	0.204124	0.204124	0	0	0	0	-0.204124	-0.204124	-0.204124	-0.204124	0	0	0	0	0.204124	0.204124
Obese	0.204124	0.204124	0	0	0	0	-0.204124	-0.204124	-0.204124	-0.204124	0	0	0	0	0.204124	0.204124

4. Food will be more skewed than Massage and Leisure (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.333333	0.333333	-0.166667	-0.166667	-0.166667	-0.166667	0	0	0	0	0	0	0	0	0	0
Control	0.333333	0.333333	-0.166667	-0.166667	-0.166667	-0.166667	0	0	0	0	0	0	0	0	0	0
Obese	0.333333	0.333333	-0.166667	-0.166667	-0.166667	-0.166667	0	0	0	0	0	0	0	0	0	0

5. Food will be more skewed than Massage and Leisure (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0.333333	0.333333	-0.166667	-0.166667	-0.166667	-0.166667	0	0
Control	0	0	0	0	0	0	0	0	0.333333	0.333333	-0.166667	-0.166667	-0.166667	-0.166667	0	0
Obese	0	0	0	0	0	0	0	0	0.333333	0.333333	-0.166667	-0.166667	-0.166667	-0.166667	0	0

6. Food will be more skewed than Massage and Leisure (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.235702	0.235702	-0.117851	-0.117851	-0.117851	-0.117851	0	0	-0.235702	-0.235702	0.117851	0.117851	0.117851	0.117851	0	0
Control	0.235702	0.235702	-0.117851	-0.117851	-0.117851	-0.117851	0	0	-0.235702	-0.235702	0.117851	0.117851	0.117851	0.117851	0	0
Obese	0.235702	0.235702	-0.117851	-0.117851	-0.117851	-0.117851	0	0	-0.235702	-0.235702	0.117851	0.117851	0.117851	0.117851	0	0

7. Massage and Leisure will be more skewed than Money (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0.166667	0.166667	0.166667	0.166667	-0.333333	-0.333333	0	0	0	0	0	0	0	0
Control	0	0	0.166667	0.166667	0.166667	0.166667	-0.333333	-0.333333	0	0	0	0	0	0	0	0
Obese	0	0	0.166667	0.166667	0.166667	0.166667	-0.333333	-0.333333	0	0	0	0	0	0	0	0

8. Massage and Leisure will be more skewed than Money (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0.166667	0.166667	0.166667	0.166667	-0.333333	-0.333333
Control	0	0	0	0	0	0	0	0	0	0	0.166667	0.166667	0.166667	0.166667	-0.333333	-0.333333
Obese	0	0	0	0	0	0	0	0	0	0	0.166667	0.166667	0.166667	0.166667	-0.333333	-0.333333

9. Massage and Leisure will be more skewed than Money (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0.117851	0.117851	0.117851	0.117851	-0.235702	-0.235702	0	0	-0.117851	-0.117851	-0.117851	-0.117851	0.235702	0.235702
Control	0	0	0.117851	0.117851	0.117851	0.117851	-0.235702	-0.235702	0	0	-0.117851	-0.117851	-0.117851	-0.117851	0.235702	0.235702
Obese	0	0	0.117851	0.117851	0.117851	0.117851	-0.235702	-0.235702	0	0	-0.117851	-0.117851	-0.117851	-0.117851	0.235702	0.235702

10. BED will be more skewed than Controls and Obese (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.288675	0.288675	0.288675	0.288675	0.288675	0.288675	0.288675	0.288675	0	0	0	0	0	0	0	0
Control	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	0	0	0	0	0	0	0	0
Obese	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	0	0	0	0	0	0	0	0

11. BED will be more skewed than Controls and Obese (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0.288675	0.288675	0.288675	0.288675	0.288675	0.288675	0.288675	0.288675
Control	0	0	0	0	0	0	0	0	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338
Obese	0	0	0	0	0	0	0	0	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338	-0.144338

12. BED will be more skewed than Controls and Obese (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.20412	0.20412	0.20412	0.20412	0.20412	0.20412	0.20412	0.20412	-0.20412	-0.20412	-0.20412	-0.20412	-0.20412	-0.20412	-0.20412	-0.20412
Control	-0.10206	-0.10206	-0.10206	-0.10206	-0.10206	-0.10206	-0.10206	-0.10206	0.10206	0.10206	0.10206	0.10206	0.10206	0.10206	0.10206	0.10206
Obese	-0.10206	-0.10206	-0.10206	-0.10206	-0.10206	-0.10206	-0.10206	-0.10206	0.10206	0.10206	0.10206	0.10206	0.10206	0.10206	0.10206	0.10206

13. Obese will be more skewed than Controls (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	0	0	0	0	0	0	0	0	0
Obese	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0	0	0	0	0	0	0	0

14. Obese will be more skewed than Controls (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	0	0	0	0	0	0	0	0	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25
Obese	0	0	0	0	0	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

15. Obese will be more skewed than Controls (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	-0.17678	-0.17678	-0.17678	-0.17678	-0.17678	-0.17678	-0.17678	-0.17678	0.17678	0.17678	0.17678	0.17678	0.17678	0.17678	0.17678	0.17678
Obese	0.17678	0.17678	0.17678	0.17678	0.17678	0.17678	0.17678	0.17678	-0.17678	-0.17678	-0.17678	-0.17678	-0.17678	-0.17678	-0.17678	-0.17678

16. Food will be more skewed than money; BED will be more skewed than Controls and Obese (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.408248	0.408248	0	0	0	0	-0.408248	-0.408248	0	0	0	0	0	0	0	0
Control	-0.204124	-0.204124	0	0	0	0	0.204124	0.204124	0	0	0	0	0	0	0	0
Obese	-0.204124	-0.204124	0	0	0	0	0.204124	0.204124	0	0	0	0	0	0	0	0

17. Food will be more skewed than money; BED will be more skewed than Controls and Obese (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0.408248	0.408248	0	0	0	0	-0.408248	-0.408248
Control	0	0	0	0	0	0	0	0	-0.204124	-0.204124	0	0	0	0	0.204124	0.204124
Obese	0	0	0	0	0	0	0	0	-0.204124	-0.204124	0	0	0	0	0.204124	0.204124

18. Food will be more skewed than money; BED will be more skewed than Controls and Obese (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.288675	0.288675	0	0	0	0	-0.288675	-0.288675	-0.288675	-0.288675	0	0	0	0	0.288675	0.288675
Control	-0.144338	-0.144338	0	0	0	0	0.144338	0.144338	0.144338	0.144338	0	0	0	0	-0.144338	-0.144338
Obese	-0.144338	-0.144338	0	0	0	0	0.144338	0.144338	0.144338	0.144338	0	0	0	0	-0.144338	-0.144338

19. Food will be more skewed than money; Obese will be more skewed than Controls (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	-0.353553	-0.353553	0	0	0	0	0.353553	0.353553	0	0	0	0	0	0	0	0
Obese	0.353553	0.353553	0	0	0	0	-0.353553	-0.353553	0	0	0	0	0	0	0	0

20. Food will be more skewed than money; Obese will be more skewed than Controls (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	0	0	0	0	0	0	0	0	-0.353553	-0.353553	0	0	0	0	0.353553	0.353553
Obese	0	0	0	0	0	0	0	0	0.353553	0.353553	0	0	0	0	-0.353553	-0.353553

21. Food will be more skewed than money; Obese will be more skewed than Controls (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	-0.25	-0.25	0	0	0	0	0.25	0.25	0.25	0.25	0	0	0	0	-0.25	-0.25
Obese	0.25	0.25	0	0	0	0	-0.25	-0.25	-0.25	-0.25	0	0	0	0	0.25	0.25

22. Food will be more skewed than Massage and Leisure, BED will be more skewed than Controls and Obese (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.471405	0.471405	-0.235702	-0.235702	-0.235702	-0.235702	0	0	0	0	0	0	0	0	0	0
Control	-0.235702	-0.235702	0.117851	0.117851	0.117851	0.117851	0	0	0	0	0	0	0	0	0	0
Obese	-0.235702	-0.235702	0.117851	0.117851	0.117851	0.117851	0	0	0	0	0	0	0	0	0	0

23. Food will be more skewed than Massage and Leisure, BED will be more skewed than Controls and Obese (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0.471405	0.471405	-0.235702	-0.235702	-0.235702	-0.235702	0	0
Control	0	0	0	0	0	0	0	0	-0.235702	-0.235702	0.117851	0.117851	0.117851	0.117851	0	0
Obese	0	0	0	0	0	0	0	0	-0.235702	-0.235702	0.117851	0.117851	0.117851	0.117851	0	0

24. Food will be more skewed than Massage and Leisure, BED will be more skewed than Controls and Obese (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0.333333	0.333333	-0.166667	-0.166667	-0.166667	-0.166667	0	0	-0.333333	-0.333333	0.166667	0.166667	0.166667	0.166667	0	0
Control	-0.166667	-0.166667	0.166667	0.083333	0.083333	0.083333	0	0	0.166667	0.166667	-0.083333	-0.083333	-0.083333	-0.083333	0	0
Obese	-0.166667	-0.166667	0.083333	0.083333	0.083333	0.083333	0	0	0.166667	0.166667	-0.083333	-0.083333	-0.083333	-0.083333	0	0

25. Food will be more skewed than Massage and Leisure; Obese will be more skewed than Controls (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	-0.408248	-0.408248	0.204124	0.204124	0.204124	0.204124	0.204124	0.204124	0	0	0	0	0	0	0	0
Obese	0.408248	0.408248	-0.204124	-0.204124	-0.204124	-0.204124	-0.204124	-0.204124	0	0	0	0	0	0	0	0

26. Food will be more skewed than Massage and Leisure; Obese will be more skewed than Controls (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	0	0	0	0	0	0	0	0	-0.408248	-0.408248	0.204124	0.204124	0.204124	0.204124	0	0
Obese	0	0	0	0	0	0	0	0	0.408248	0.408248	-0.204124	-0.204124	-0.204124	-0.204124	0	0

27. Food will be more skewed than Massage and Leisure; Obese will be more skewed than Controls (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	-0.288675	-0.288675	0.144338	0.144338	0.144338	0.144338	0	0	0.288675	0.288675	-0.144338	-0.144338	-0.144338	-0.144338	0	0
Obese	0.288675	0.288675	-0.144338	-0.144338	-0.144338	-0.144338	0	0	-0.288675	-0.288675	0.144337567	0.144337567	0.144337567	0.144337567	0	0

28. Massage and Leisure will be more skewed than Money; BED will be more skewed than Controls and Obese (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0.235702	0.235702	0.235702	0.235702	-0.471405	-0.471405	0	0	0	0	0	0	0	0
Control	0	0	-0.117851	-0.117851	-0.117851	-0.117851	0.235702	0.235702	0	0	0	0	0	0	0	0
Obese	0	0	-0.117851	-0.117851	-0.117851	-0.117851	0.235702	0.235702	0	0	0	0	0	0	0	0

29. Massage and Leisure will be more skewed than Money; BED will be more skewed than Controls and Obese (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0.235702	0.235702	0.235702	0.235702	-0.471405	-0.471405
Control	0	0	0	0	0	0	0	0	0	0	-0.117851	-0.117851	-0.117851	-0.117851	0.235702	0.235702
Obese	0	0	0	0	0	0	0	0	0	0	-0.117851	-0.117851	-0.117851	-0.117851	0.235702	0.235702

30. Massage and Leisure will be more skewed than Money; BED will be more skewed than Controls and Obese (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0.166667	0.166667	0.166667	0.166667	-0.333333	-0.333333	0	0	-0.166667	-0.166667	-0.166667	-0.166667	0.333333	0.333333
Control	0	0	-0.083333	-0.083333	-0.083333	-0.083333	0.166667	0.166667	0	0	0.083333	0.083333	0.083333	0.083333	-0.166667	-0.166667
Obese	0	0	-0.083333	-0.083333	-0.083333	-0.083333	0.166667	0.166667	0	0	0.083333	0.083333	0.083333	0.083333	-0.166667	-0.166667

31. Massage and Leisure will be more skewed than Money, Obese will be more skewed than Controls (delay)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	0	0	-0.204124	-0.204124	-0.204124	-0.204124	0.408248	0.408248	0	0	0	0	0	0	0	0
Obese	0	0	0.204124	0.204124	0.204124	0.204124	-0.408248	-0.408248	0	0	0	0	0	0	0	0

32. Massage and Leisure will be more skewed than Money, Obese will be more skewed than Controls (probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	0	0	0	0	0	0	0	0	0	0	-0.204124	-0.204124	-0.204124	-0.204124	0.408248	0.408248
Obese	0	0	0	0	0	0	0	0	0	0	0.204124	0.204124	0.204124	0.204124	-0.408248	-0.408248

33. Massage and Leisure will be more skewed than Money, Obese will be more skewed than Controls (delay vs. probability)

	Food sm delay	Food lg delay	Leisure sm delay	Leisure lg delay	Massage sm delay	Massage lg delay	Money sm delay	Money lg delay	Food sm prob	Food lg prob	Leisure sm prob	Leisure lg prob	Massage sm prob	Massage lg prob	Money sm prob	Money lg prob
BED	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Control	0	0	-0.144338	-0.144338	-0.144338	-0.144338	0.288675	0.288675	0	0	0.144338	0.144338	0.144338	0.144338	-0.288675	-0.288675
Obese	0	0	0.144338	0.144338	0.144338	0.144338	-0.288675	-0.288675	0	0	-0.144338	-0.144338	-0.144338	-0.144338	0.288675	0.288675